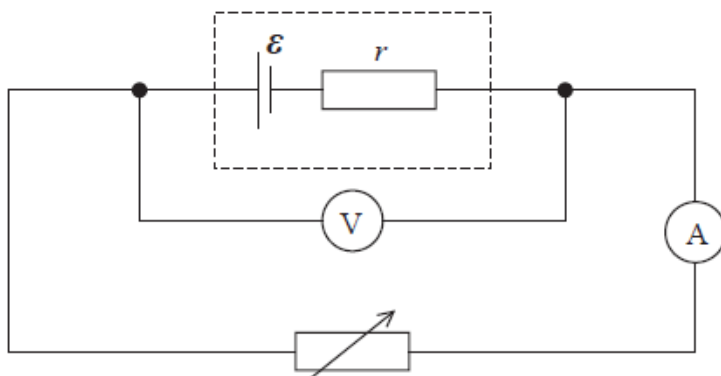


Questions

Q1.

The diagram shows a circuit used to determine the internal resistance r and e.m.f. $\mathcal{E}$ of a cell.



Corresponding values of potential difference V and current I were taken after adjusting the variable resistor. A graph of V on the y -axis against I on the x -axis was plotted.

Which of the following is correct?

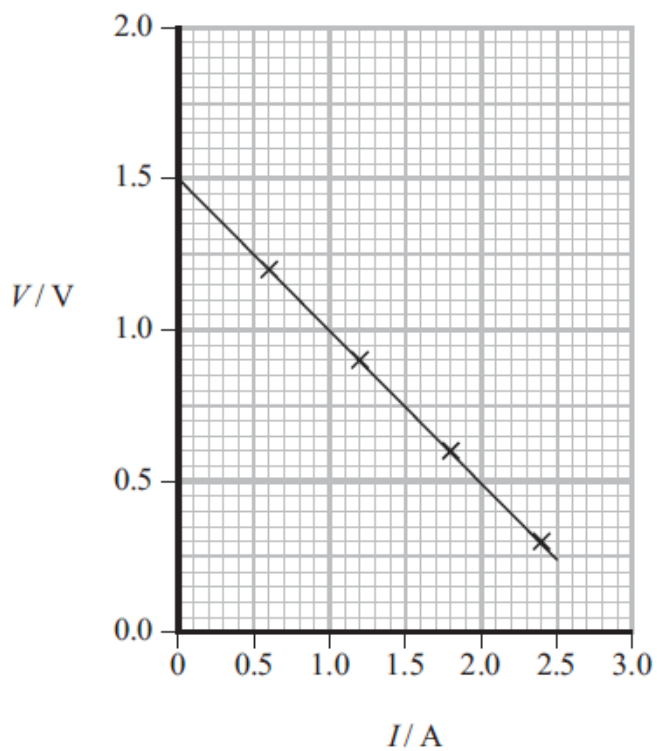
- ☐ **A** The area underneath the graph is the total energy dissipated in the cell.
- ☐ **B** The gradient of the graph is r .
- ☐ **C** The graph shows that V and I are directly proportional.
- ☐ **D** The y -intercept of the graph is $\mathcal{E}$.

(Total for question = 1 mark)

Q2.

A student investigated how the potential difference V across a battery varied with current I in the battery.

The student plotted her results on a graph, as shown.



Determine the e.m.f. and internal resistance of the battery.

.....

.....

.....

.....

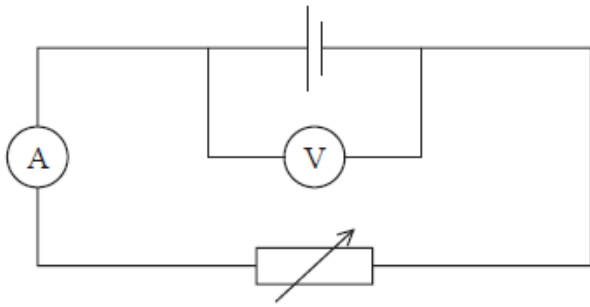
e.m.f. = ...

Internal resistance = ...

(Total for question = 3 marks)

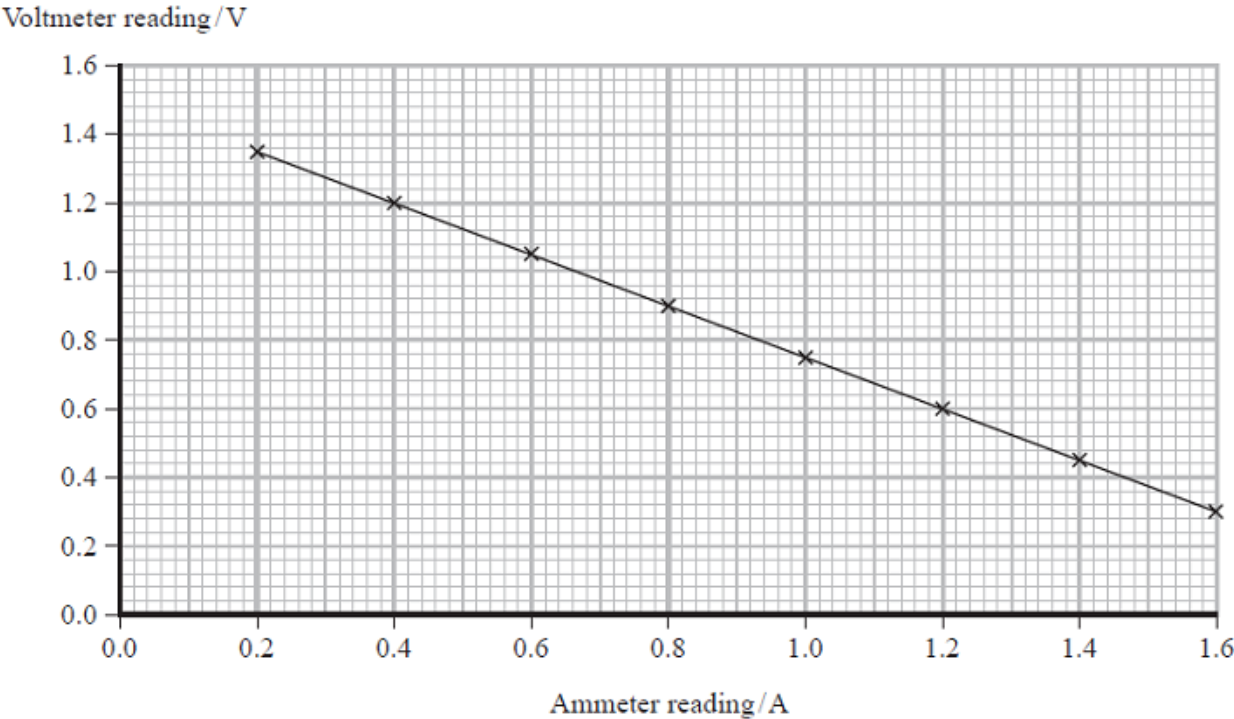
Q3.

A student investigated the internal resistance of a cell, using the circuit shown.



The student used the variable resistor to vary the reading on the ammeter. He recorded corresponding readings from the voltmeter.

The student plotted the results on a graph, as shown.



(a) Determine the e.m.f. $\mathcal{E}$ of the cell, and the internal resistance r of the cell.

(3)

.....

.....

.....

.....

.....

$\mathcal{E} =$

$r =$

(b) The student placed an identical cell in series with the original cell in the circuit. He connected the voltmeter across both cells and repeated the investigation.

The student plotted a new graph of these voltmeter and ammeter readings.

Describe how the new graph is different from the graph for one cell.

(2)

.....

.....

.....

.....

(Total for question = 5 marks)

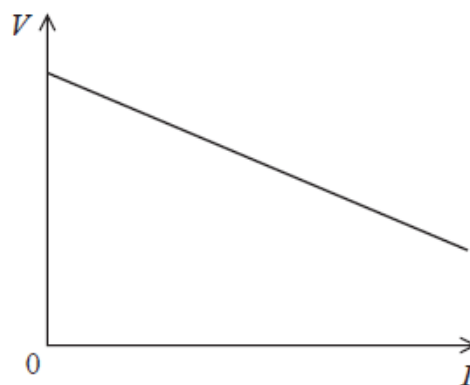
Q4.

A student carries out an experiment to determine the e.m.f. $\mathcal{E}$ and internal resistance r of an electrical cell, using a circuit containing an ammeter and a voltmeter.

(a) Draw a diagram of a circuit that can be used for this experiment.

(3)

(b) The student plotted a graph of the terminal potential difference V of the cell against the current I in the cell, as shown.



Explain how $\mathcal{E}$ and r for the cell can be determined from this graph.

(4)

.....

.....

.....

.....

.....

.....

.....

(Total for question = 7 marks)

Q5.

A student investigated the e.m.f. and internal resistance of a battery.

(a) The student connected a high resistance voltmeter across the battery. The battery was not connected to any other components.

Explain why the reading on the voltmeter gave the e.m.f. of the battery.

(2)

.....

.....

.....

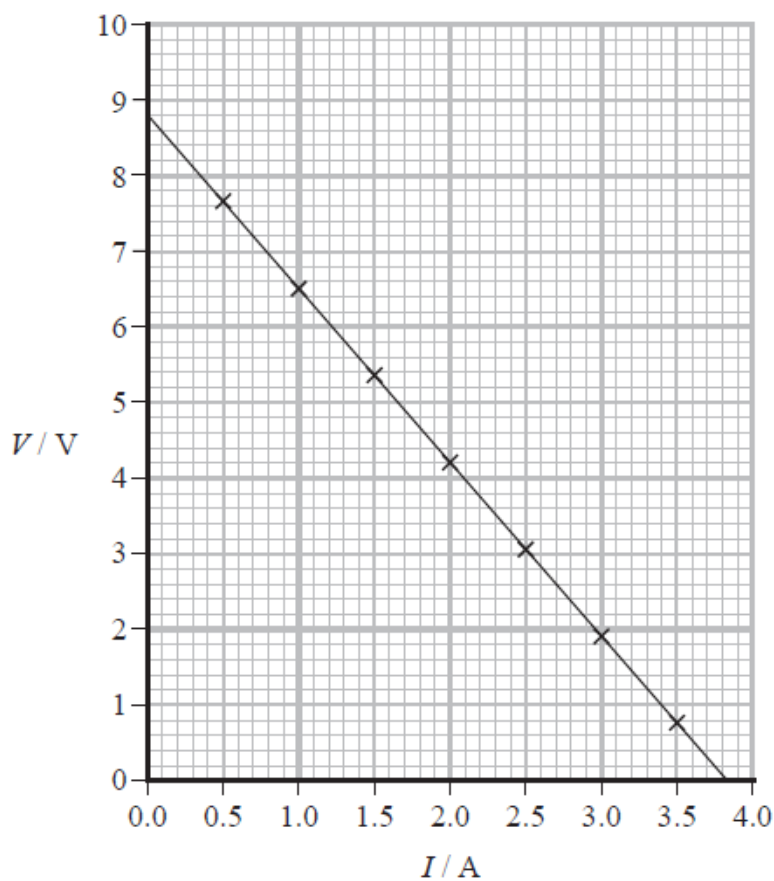
.....

(b) The student investigated how the potential difference V across the battery varied with the current I in the battery.

Draw a circuit diagram for this investigation.

(2)

(c) The student plotted her results on a graph as shown.



(i) Determine the e.m.f. and internal resistance of the battery.

(3)

.....

.....

.....

.....

emf = ...

Internal resistance = ...

(ii) Explain why there is a maximum current that can be supplied by the battery.

(2)

.....

.....

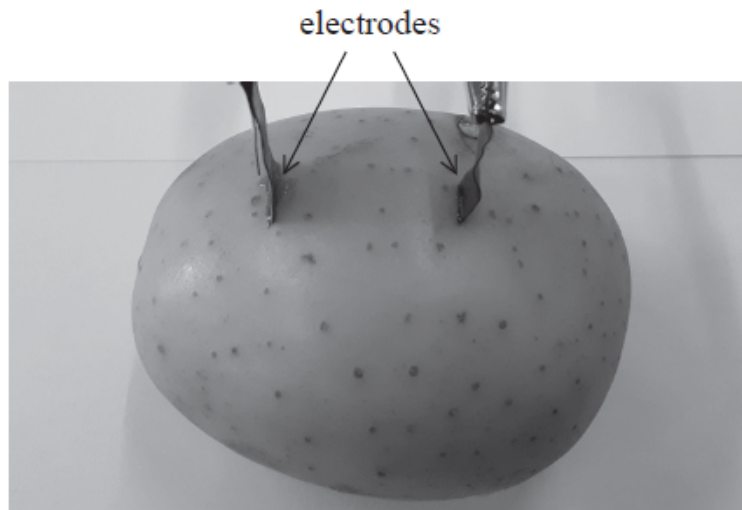
.....

.....

(Total for question = 9 marks)

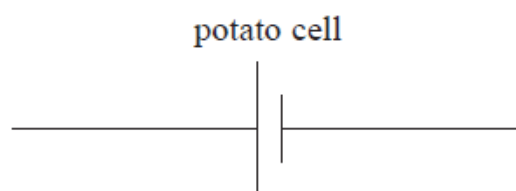
Q6.

A student carried out an experiment to determine the e.m.f. ε and internal resistance r of a potato cell. The potato used in the experiment was connected to the rest of the circuit using electrodes of two different metals as shown.

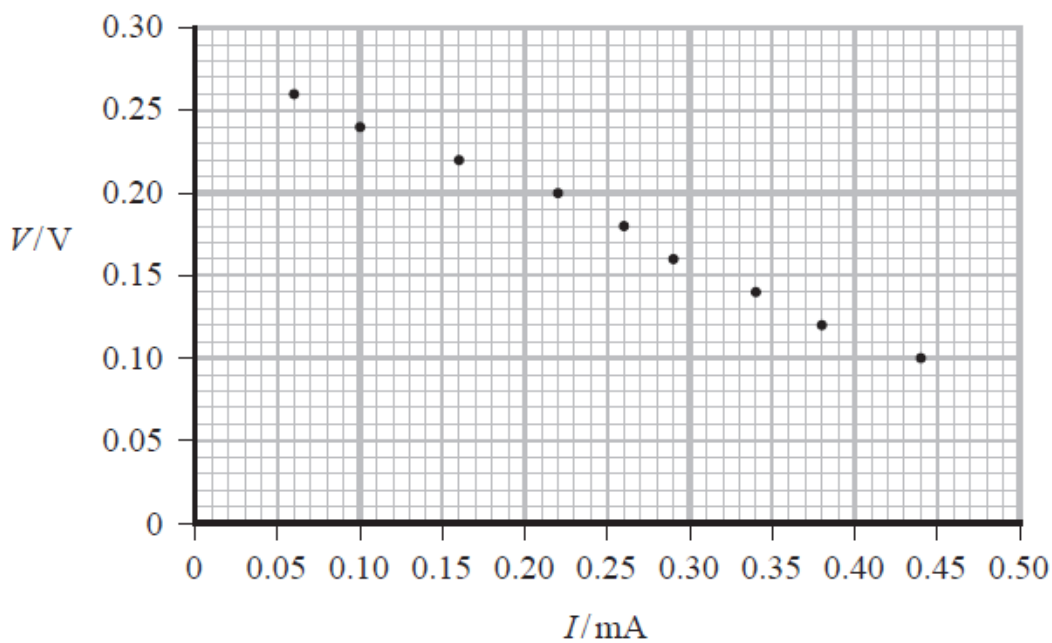


(a) Complete the diagram below to show a circuit that could be used in order to determine ε and r for the potato cell.

(2)



(b) The student completed the experiment and plotted a graph showing the relationship between potential difference V and current I as shown.



Use the graph to determine values for ε and r .

(4)

.....

.....

.....

.....

.....

.....

.....

.....

$\varepsilon =$

$r =$

(c) In a separate experiment two resistors, with equal resistance R , are connected to a battery (with internal resistance r) with the two resistors firstly in a series arrangement (diagram A) and then in a parallel arrangement (diagram B).

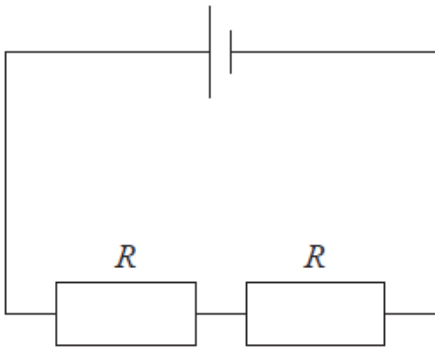


Diagram A

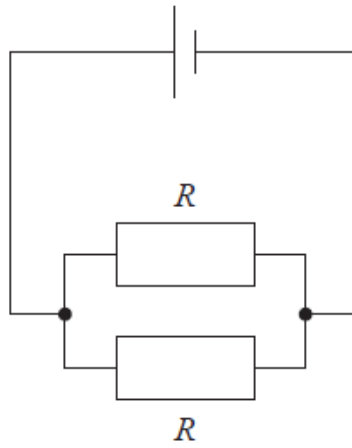


Diagram B

Explain which, if either, of the two arrangements would lead to a greater value for the terminal potential difference.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

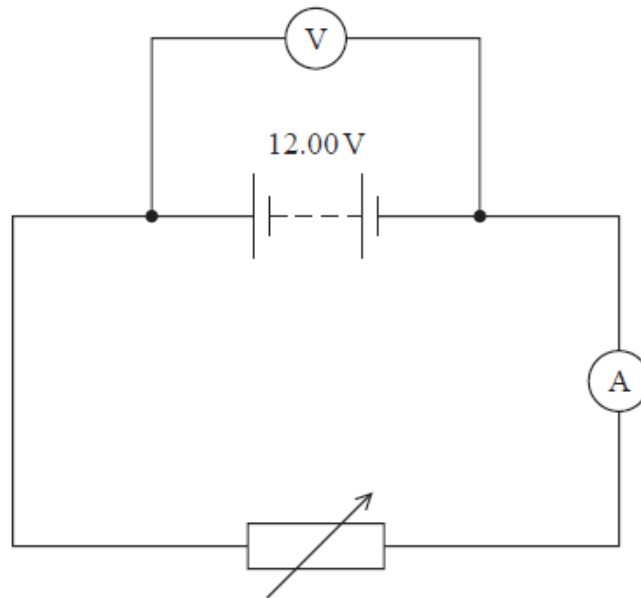
Q7.

A car battery is constructed using six cells connected in series, with a combined electromotive force (e.m.f.) of 12.00 V.

(a) State what is meant by e.m.f.

(1)

.....
.....
(b) A student set up the circuit shown, using the car battery.



The student adjusted the variable resistor until the reading on the voltmeter was 11.81 V. The reading on the ammeter was 9.83 A.

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

(2)

.....
.....
.....
Internal resistance = ...

(ii) The student adjusted the variable resistor several times and recorded corresponding values from the ammeter and voltmeter.

Describe how the values can be used to determine the internal resistance of the battery using a graphical method.

(3)

.....
.....
.....
.....

.....

.....

(c) With use, the internal resistance of a battery will increase. Eventually the power available from a battery will become too small to be useful.

The student calculated the power available from a battery of e.m.f 9.0 V and internal resistance $0.10\ \Omega$ when connected across a $5.0\ \Omega$ resistor.

He concluded that when the internal resistance had risen to $0.50\ \Omega$, the power dissipated in the $5.0\ \Omega$ resistor would reduce to 70% of its original value.

Determine whether the student's conclusion is correct.

(4)

.....

.....

.....

.....

.....

.....

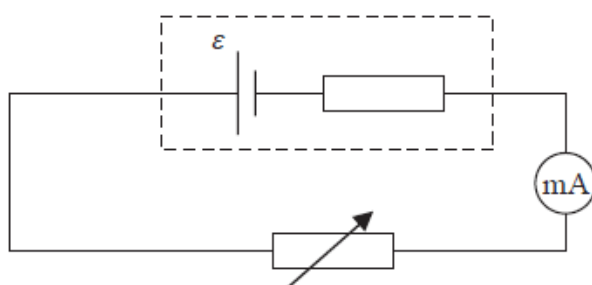
.....

.....

(Total for question = 10 marks)

Q8.

A cell of e.m.f. ϵ is connected in series with a variable resistor with resistance R as shown. The internal resistance of the cell is r .



When R is $12\ \Omega$, the reading on the ammeter is $107\ \text{mA}$. The circuit is switched on for 300 seconds. In this time, $50\ \text{J}$ of energy is transferred by the cell.

(a) Calculate r .

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

$r =$

(b) Increasing R would make the terminal potential difference value closer to ϵ .

Explain why, without further calculation.

(2)

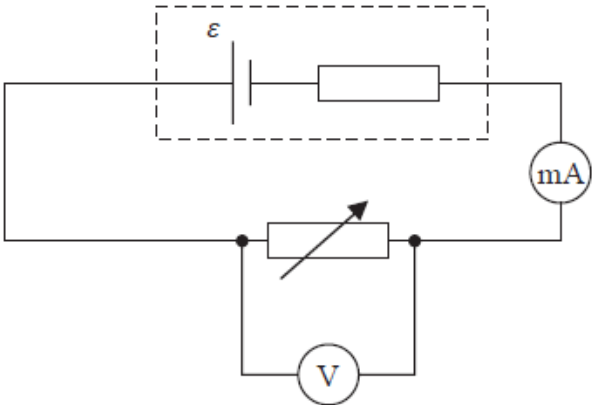
.....

.....

.....

.....

(c) A voltmeter is added to the circuit as shown.



Explain how this circuit can be used to determine a value for r using a graphical method.

(4)

.....

.....

.....

.....

.....

.....

.....

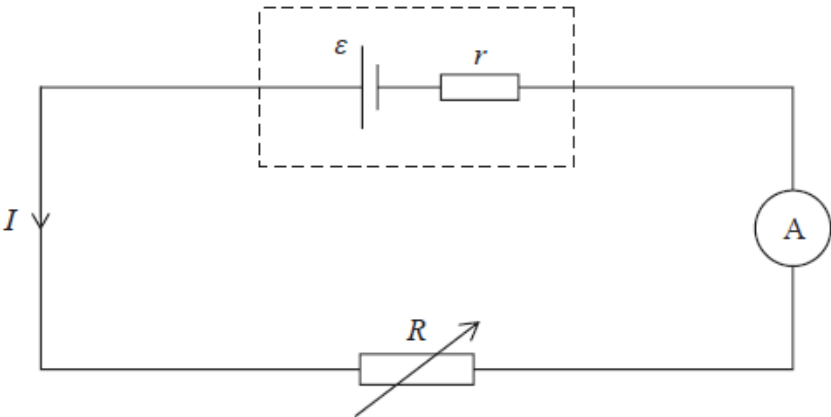
.....

(Total for question = 11 marks)

Q9.

A student set up the circuit shown to determine the e.m.f. ε and internal resistance r of a cell.

I is the current in the circuit and R is the resistance of the variable resistor.



(a) Show that, for this circuit, $R = \frac{\varepsilon}{I} - r$

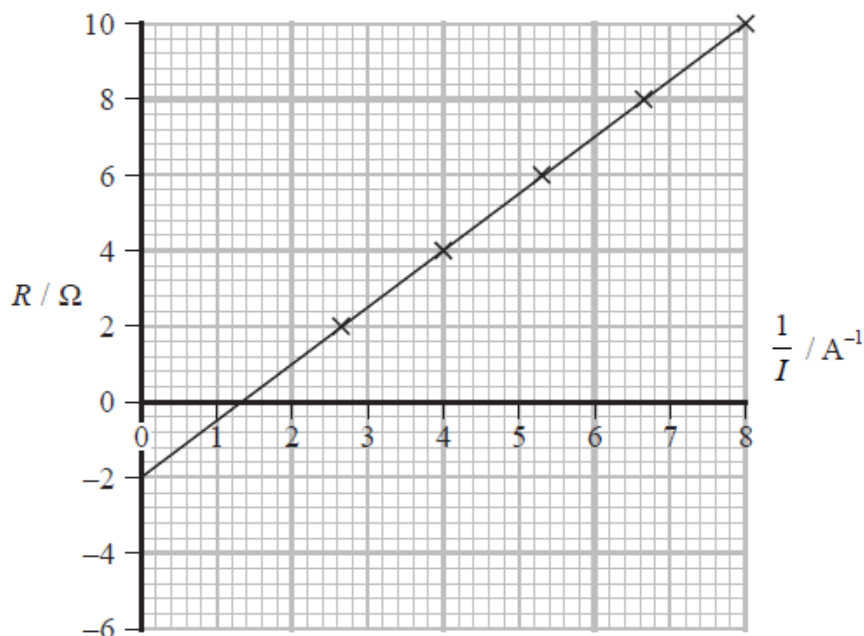
(2)

.....

.....

(b) The student varied R and measured corresponding values of I .

The student then plotted a graph of R against $\frac{1}{I}$ as shown.



Determine values of ε and r for the cell.

(3)

$\varepsilon =$

$r =$

(c) The student suggested that the power dissipated by the internal resistance r decreases as R increases.

Comment on the student's suggestion.

No further calculations are required.

(3)

.....
.....
.....
.....
(d) The student added a second, identical cell in series with the first cell and repeated the experiment.

Add a line to the graph to show the result of this experiment.

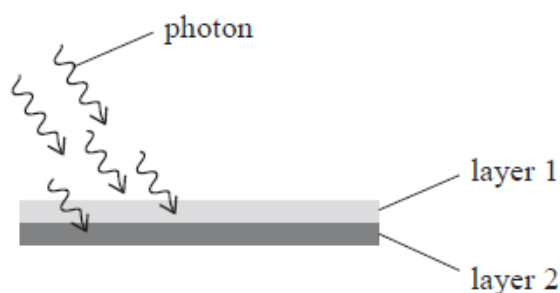
(3)

(Total for question = 11 marks)

Q10.

Solar cells are made from semiconductor materials.

One type of solar cell has two layers of semiconducting material, layer 1 and layer 2. Photons of light are incident on the solar cell as shown. The minimum energy to release an electron from a semiconductor layer is the work function.



(a) The work function of layer 1 is 1.86 eV.

Calculate the minimum frequency of light needed to release an electron from layer 1.

(3)

.....
.....
.....
.....
.....
.....

Minimum frequency = ...

(b) Light from the Sun is incident on the solar cell. The intensity of the incident light is constant.

Layer 1 has a greater work function than layer 2. Photons not absorbed by layer 1 are transmitted to layer 2.

Layer 1 is removed from the solar cell so that all photons now reach layer 2.

Explain how removing layer 1 affects the rate at which electrons are released in the solar cell.

You should assume that each layer absorbs all photons with a frequency greater than the minimum frequency for that layer.

(5)

.....

.....

.....

.....

.....

.....

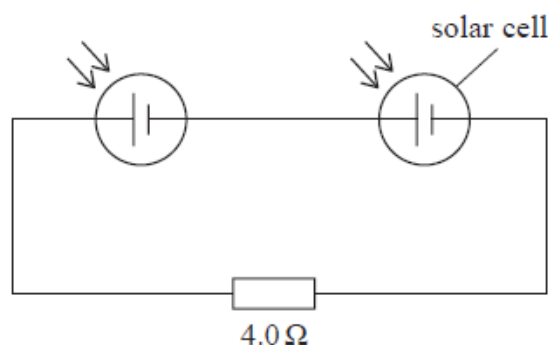
.....

.....

.....

.....

(c) A student connected two solar cells in series with a $4.0\ \Omega$ resistor as shown.



The student adjusted the light conditions so that each solar cell had an e.m.f. of 5.0 V and an internal resistance of $0.80\ \Omega$.

The power dissipated in the resistor was 13 W .

The student suggested that connecting the cells in parallel would cause the power dissipated in the resistor to be less than half this value.

Deduce whether the student's suggestion is correct.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 13 marks)