A-Level Physics

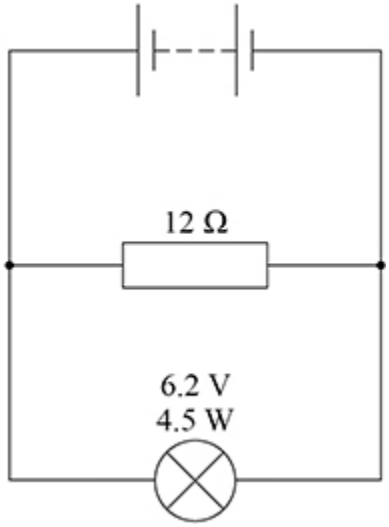
Electromotive Force

Question Paper

Time available: 72 minutes
Marks available: 55 marks

1. A student assembles the circuit in **Figure 1**.

Figure 1



The battery has an internal resistance of $2.5\ \Omega$.

(a) Show that the resistance of the $6.2\ \text{V}, 4.5\ \text{W}$ lamp at its working potential difference (pd) is about $9\ \Omega$.

(1)

(b) The terminal pd across the battery is $6.2\ \text{V}$.

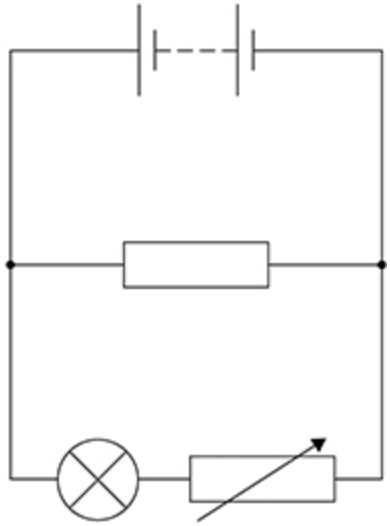
Calculate the emf of the battery.

emf = _____ V

(3)

The student makes a variable resistor to control the brightness of the lamp. **Figure 2** shows her circuit.

Figure 2



(c) She uses a resistance wire with a diameter of $0.19\ \text{mm}$ to make the variable resistor. A $5.0\ \text{m}$ length of this wire has a resistance of $9.0\ \Omega$.

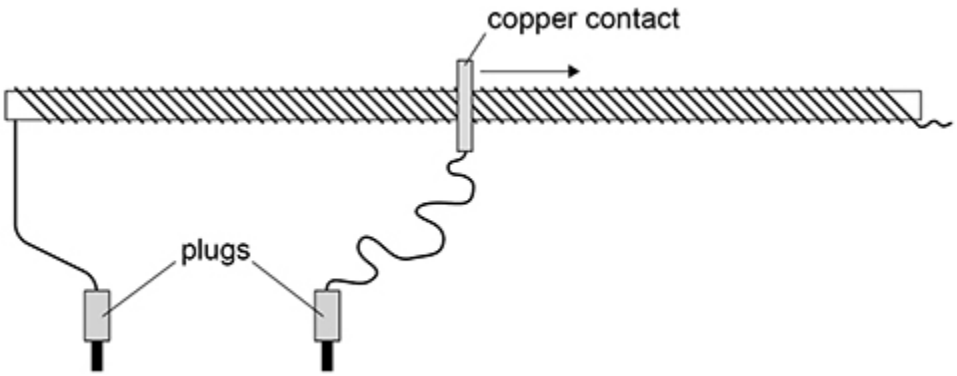
Calculate the resistivity of the wire.

resistivity = _____ $\Omega\ \text{m}$

(3)

(d) **Figure 3** shows the $5.0\ \text{m}$ length of wire wrapped around a tube to make the variable resistor.

Figure 3



Two plugs connect the variable resistor into the circuit. A moveable copper contact is used to vary the length of wire in series with the lamp.
When the contact is placed on the tube at one particular position, the lamp is dim.
The contact is then moved slowly to the right as shown in **Figure 3**.

Explain, without calculation, what happens to the brightness of the lamp as the contact is moved.

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(2)

(e) The student now makes a different circuit by connecting the variable resistor **in parallel** with the lamp.

The contact is returned to its original position on the tube as shown in **Figure 3** and the lamp is dim. The contact is again slowly moved to the right.

Explain, without calculation, what happens to the brightness of the lamp as the contact is moved.

(2)

(Total 11 marks)

2. A cell has an emf of 1.5 V and an internal resistance of 0.65 Ω.
The cell is connected to a resistor **R**.

(a) State what is meant by an emf of 1.5 V.

(2)

(b) The current in the circuit is 0.31 A.

Show that the total power output of the cell is approximately 0.47 W.

(1)

(c) Calculate the energy dissipated per second in resistor **R**.

energy dissipated per second = _____ J s^{-1}

(2)

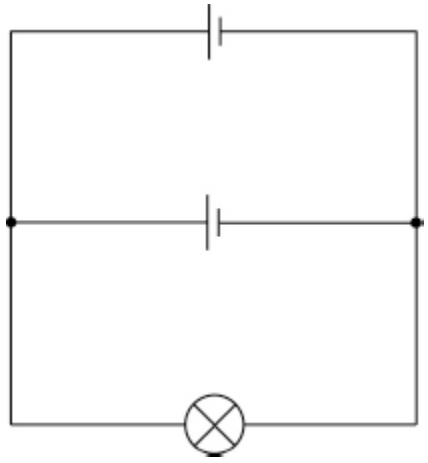
(d) The cell stores 14 kJ of energy when it is fully charged. The cell's emf and internal resistance are constant as the cell is discharged.

Calculate the maximum time during which the fully-charged cell can deliver energy to resistor **R**.

maximum time = _____ s

(2)

(e) A student uses two cells, each of emf 1.5 V and internal resistance 0.65 Ω, to operate a lamp. The circuit is shown in the diagram.



The lamp is rated at 1.3 V, 0.80 W.

Deduce whether this circuit provides the lamp with 0.80 W of power at a potential difference (pd) of 1.3 V.
Assume that the resistance of the lamp is constant.

(4)

(f) The lamp operates at normal brightness across a pd range of 1.3 V to 1.5 V.

State and explain how more of these cells can be added to the circuit to make the lamp light at normal brightness for a longer time.
No further calculations are required.

(3)

(Total 14 marks)

3. (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.

(1)

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

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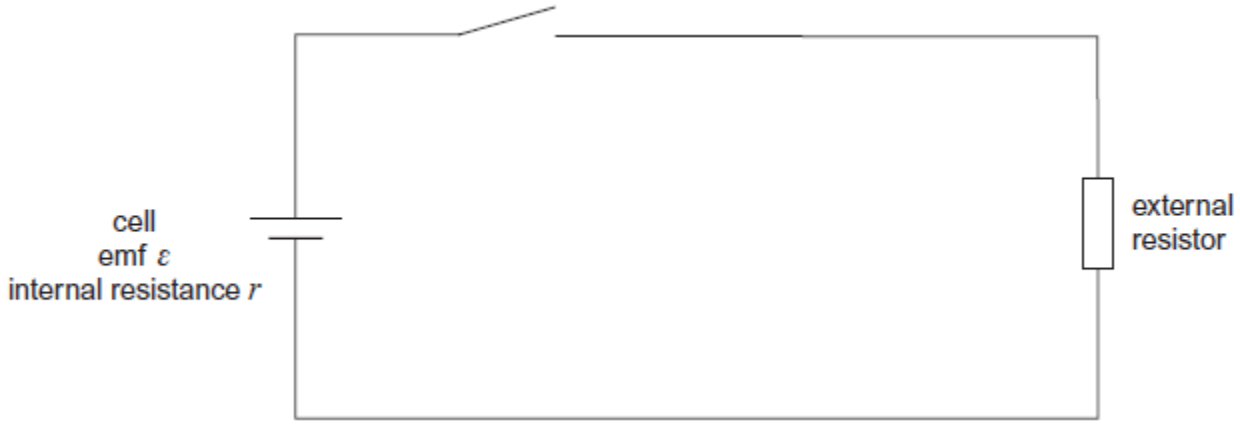
_____

(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.

(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.

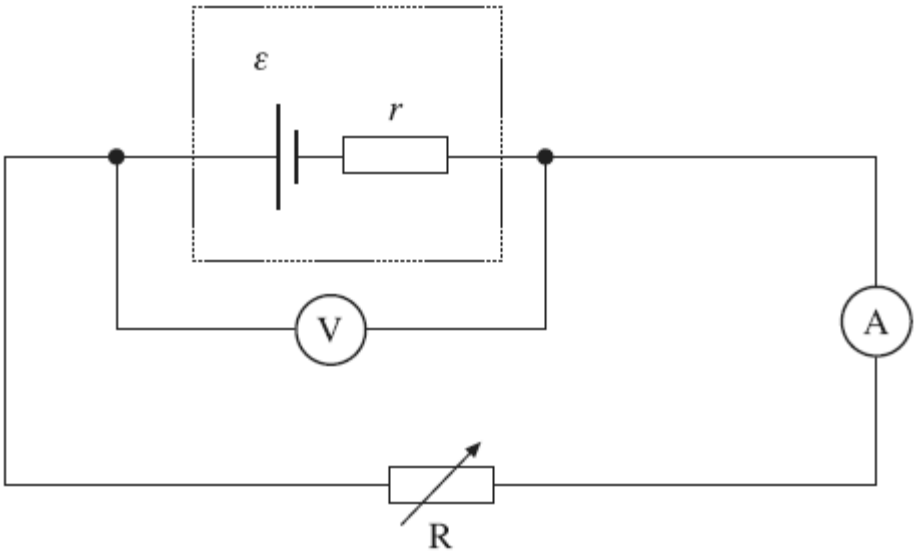
(2)

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

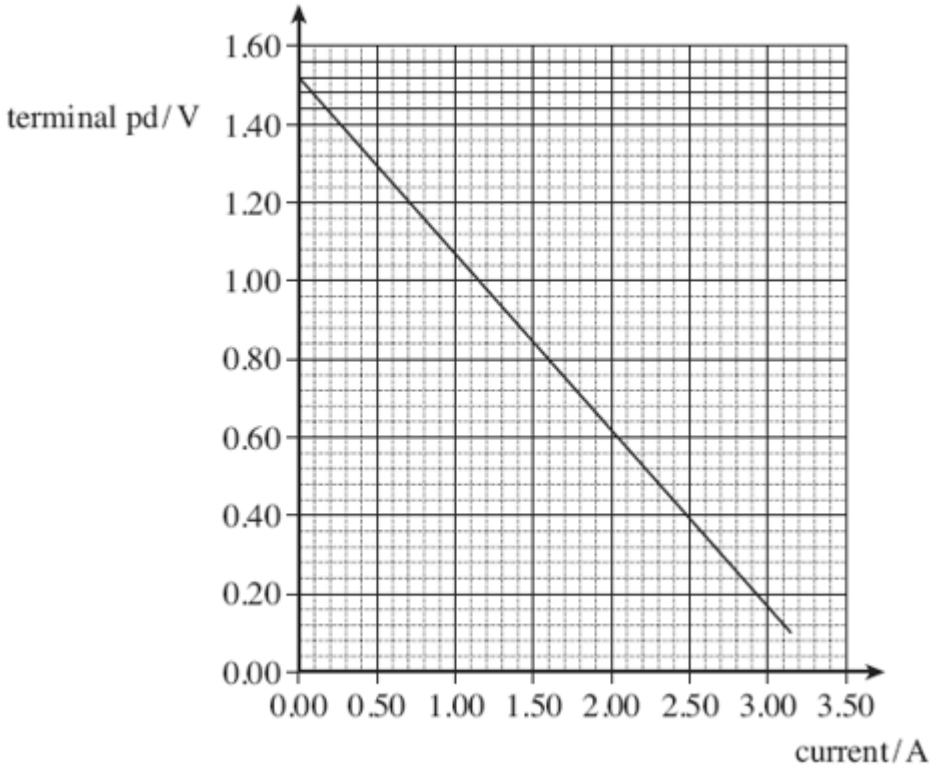
(2)

(Total 9 marks)

4. 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.

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(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)

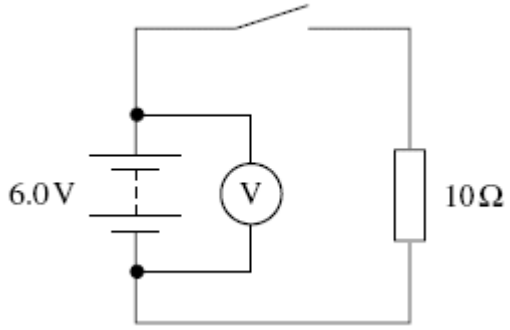
(ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = _____ W

(2)

(Total 13 marks)

5. A battery is connected to a 10 Ω resistor as shown in the diagram below. The emf (electromotive force) of the battery is 6.0 V.



(a) (i) Define the emf of a battery.

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_____

(1)

(ii) When the switch is open the voltmeter reads 6.0 V and when it is closed it reads 5.8 V.
Explain why the readings are different.

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_____

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_____

(2)

(b) Calculate the internal resistance of the battery.

answer = _____ Ω

(3)

(c) State and explain why it is important for car batteries to have a very low internal resistance.

_____

_____

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_____

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_____

(2)

(Total 8 marks)