5.3 Electric Cells

Question Paper

Course	DP IB Physics
Section	5. Electricity & Magnetism
Topic	5.3 Electric Cells
Difficulty	Hard

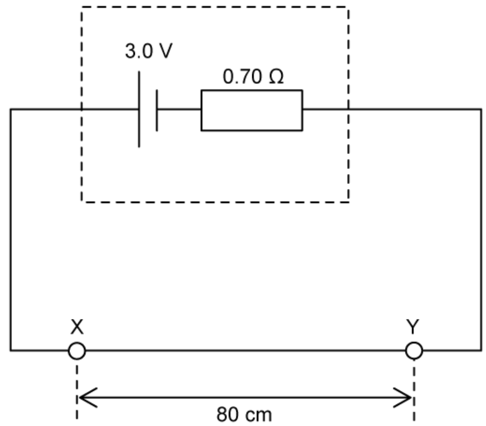
Time allowed: 60

Score: /48

Percentage: /100

Question 1a

A uniform wire of length 80 cm and radius 0.50 mm is connected in series with a cell of e.m.f. 3.0 V and an internal resistance of 0.70 Ω.



The resistivity of the metal used to make the wire is 1.10×10^{-6} Ω m.

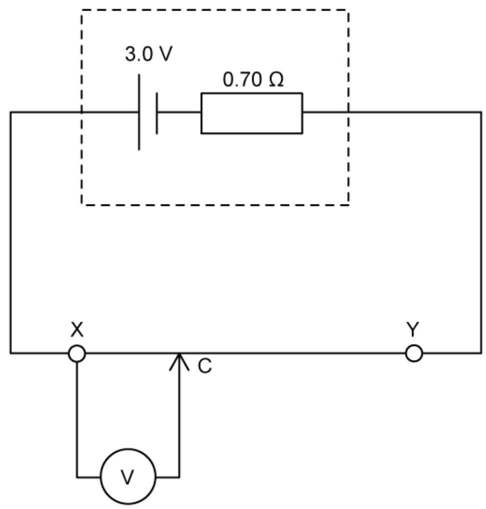
(a)
Determine the current that flows in the cell.

[2]

[2 marks]

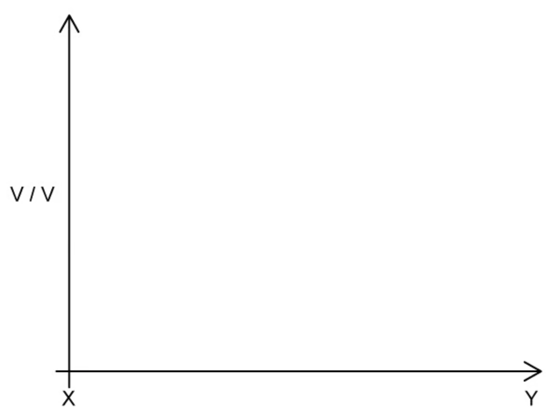
Question 1b

A voltmeter is connected at X, with a movable probe C, such that the voltmeter is able to read the potential difference across the wire at different points between X and Y.



(b)

Sketch a graph on the set of axes below which shows how the potential difference V varies between X and Y as the sliding contact C moves from X to Y.

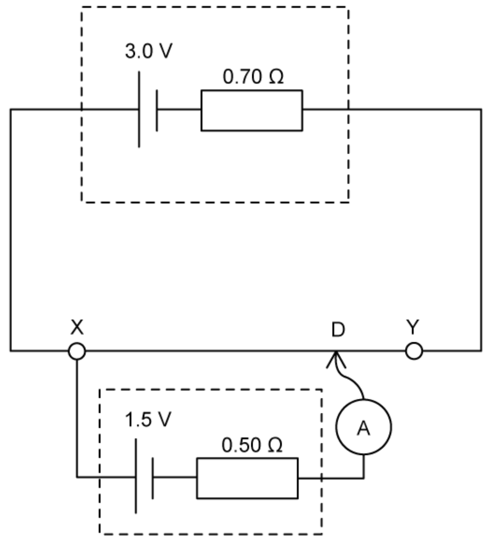


[4]

[4 marks]

Question 1c

The voltmeter in (b) is replaced with a cell of e.m.f. 1.5 V with internal resistance 0.50 Ω, and an ammeter:



The moveable contact can again be connected to any point along the wire XY. At point D, there is zero current in the ammeter.

(c)
Calculate the length of XD.

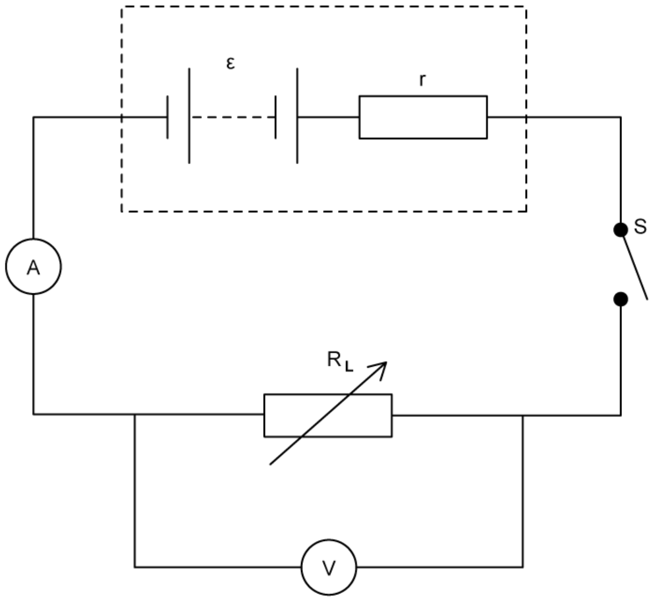
[4]

[4 marks]

Question 2a

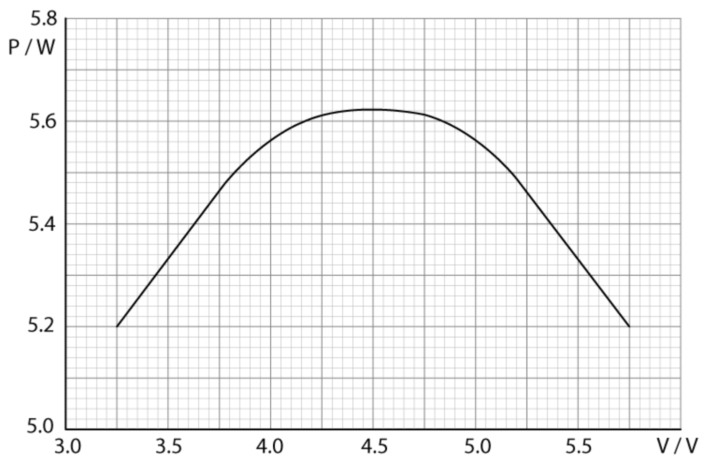
The Maximum Power Transfer theorem says the maximum amount of electrical power is dissipated in a load resistance R_L when it is exactly equal to the internal resistance of the power source *r*.

The circuit below is used to investigate maximum power transfer.



A variable resistor, which acts as the load resistance R_L, is connected to a power source of e.m.f. ε and internal resistance *r*, along with a switch *S* and an ammeter and voltmeter.

The graph below shows the results obtained for the power *P* dissipated in R_L as the potential difference *V* across R_L is varied:



(a)
Assuming the Maximum Power Theorem is valid, use the graph to determine the internal resistance of the power source.

[3]

[3 marks]

Question 2b

(b)

Show that the e.m.f. of the power supply is 9 V.

[3]

[3 marks]

Question 2c

(c)

Identify what happens to each of the following quantities as the value of the load resistance R_L becomes infinitely large:

(i)

Current.

[1]

(ii)

Potential difference across R_L.

[1]

(iii)

Power dissipated in R_L.

[1]

[3 marks]

Question 2d

It can be shown that the power P dissipated in the load resistance R_L is zero when the load resistance is zero.

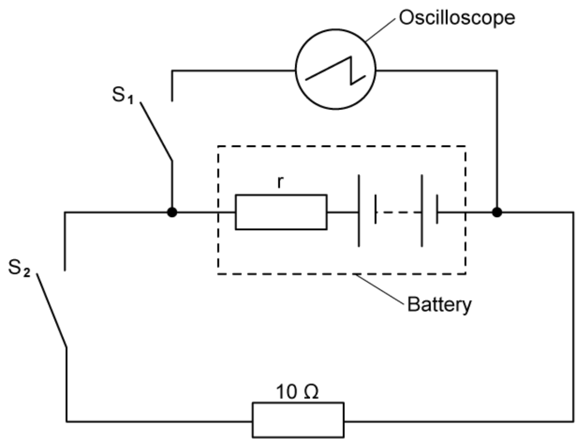
(d)
Sketch a graph on the axes provided to show how the power dissipated P varies with load resistance R_L.
Label the position of the internal resistance, r.

[3]

[3 marks]

Question 3a

The diagram shows a circuit which can be used to investigate the internal resistance *r* of a power supply. In this case, a battery consisting of six dry cells in series, each of e.m.f. $\varepsilon = 0.5$ V, is connected to an oscilloscope:



The chart below represents the trace shown on the oscilloscope screen when both of the switches S_1 and S_2 are open:

The y-gain of the oscilloscope is set at 1.5 V div^{-1}.

(a)
Discuss what happens to the trace shown on the oscilloscope screen when switch S_1 is closed.

[4]

[4 marks]

Question 3b

(b)

Draw the trace on the oscilloscope screen when both switches S_1 and S_2 are closed. Explain your answer.

[3]

[3 marks]

Question 3c

(c)

Calculate the internal resistance of the battery if the vertical distance between the traces in part (a) and part (b) is measured to be half a division.

[3]

[3 marks]

Question 3d

(d)

Determine the current in the cell that would move the trace shown on the oscilloscope screen back to its original position as shown in part a. Assume both switches, S_1 and S_2, remain closed.

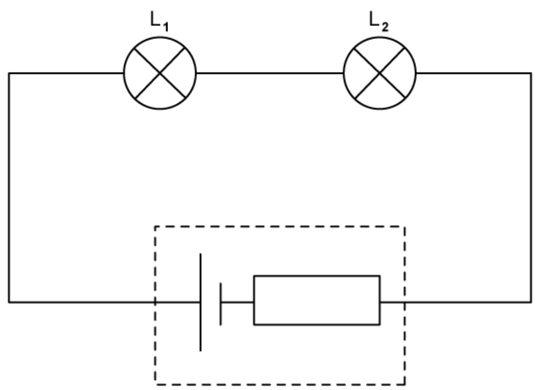
[2]

[2 marks]

Question 4a

Understanding the properties of e.m.f. and internal resistance can help the design decisions of architects and electrical engineers.

In an experiment to investigate power dissipation across two lamps, L_1 and L_2, an engineer connects them in a series circuit to a cell of e.m.f. 45 V and internal resistance 7 Ω.



The lamp L_1 has a resistance of 10 Ω and L_2 has a resistance of 25 Ω.

(a)
Calculate the percentage difference between the power generated by the cell and the power dissipated in the two lamps L_1 and L_2. Suggest a reason for this percentage difference.

[5]

[5 marks]

Question 4b

The engineer wishes to maximise the power dissipated across each lamp and explores various alternatives to the circuit shown in part a.

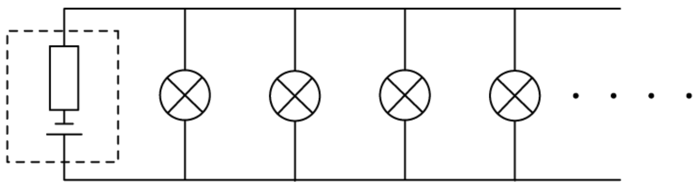
(b)
Suggest and explain, using appropriate calculations, how the engineer should arrange the lamps L_1 and L_2 such that the power dissipated in each lamp is maximised.

[6]

[6 marks]

Question 4c

The engineer comes up with a theoretical problem, which involves arranging a large number of identical lamps in parallel with each other, as illustrated below:



The lamps are connected to a cell of e.m.f. ε and internal resistance *r*.

(c)
Discuss the effect on the terminal p.d. supplied by the cell, and hence on the lamps, as more lamps are added in parallel.

[3]

[3 marks]