A Level · OCR · Physics

38 mins · 3 questions

Structured Questions

E.m.f & Internal Resistance

E.m.f & Internal Resistance / Calculating E.m.f / Determining Internal Resistance / E.m.f & Potential Difference / Energy Transfer

Medium (2 questions)	/25
Hard (1 question)	/13
Total Marks	**/38**

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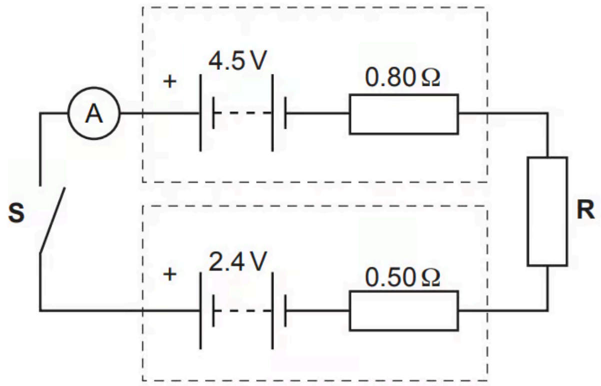
Medium Questions

1 (a) The circuit diagram of an electrical circuit is shown below.



The positive terminals of the batteries are connected together.

One battery has electromotive force (e.m.f.) 4.5 V and internal resistance 0.80 Ω.

The other battery has e.m.f. 2.4 V and internal resistance 0.50 Ω.

R is a coil of insulated wire of resistance 1.2 Ω at room temperature.

The switch **S** is closed.

i) On the diagram, draw an arrow to show the direction of the conventional current.

[1]

ii) Calculate the current *I* shown by the ammeter.

I = ... A **[3]**

iii) The insulated wire has a diameter 4.6×10^{-4} m.

The number density of charge carriers in **R** is 4.2×10^{28} m^{-3}.

Calculate the mean drift velocity *v* of the charge carriers in **R**.

v = ... m s^{-1} **[2]**

iv) The current measured by the ammeter is smaller than that calculated in **(ii)**. This is because the temperature of **R** increased due to heating by the current.

Without any changes to the circuit itself, state and explain what practically can be done to make the measured current the same as the calculated current.

[2]

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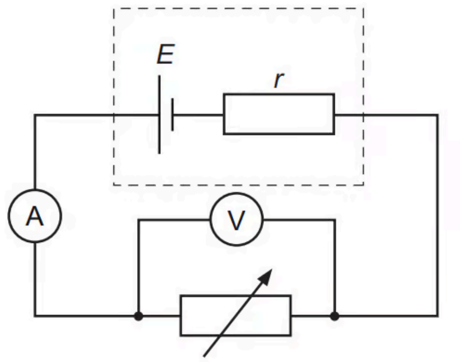
(8 marks)

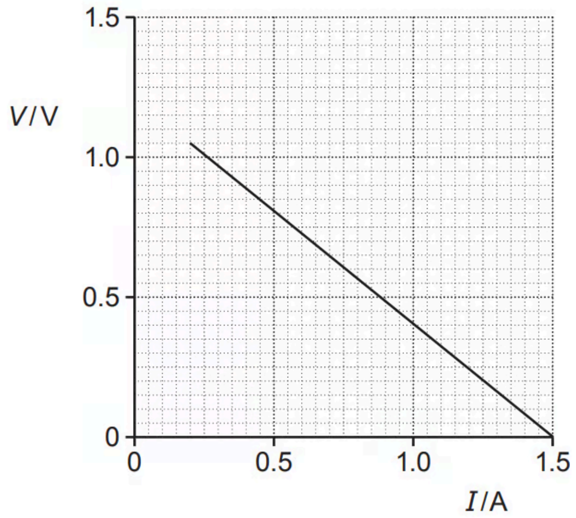
(b) A student is doing an experiment to determine the e.m.f. *E* of a cell and its internal resistance *r*.

The circuit diagram of the arrangement is shown below.



The student changes the resistance of the variable resistor. The potential difference *V* across the variable resistor and the current *I* in the circuit are measured.

The V against I graph plotted by the student is shown below.



V/V	I/A	R/Ω	P/W
0.20	1.25		
0.40	1.00		
0.60	0.75		
0.80	0.50		
1.00	0.25		

There is an incomplete table next to the graph. R is the resistance of the variable resistor and P is the power dissipated by the variable resistor.

- Use the graph to determine E and r. Explain your reasoning.

- Calculate R and P to complete the table. Describe how P depends on R.

(6 marks)

2 (a) Derive the S.I. base units for resistance.

base units: ....

....

....

(2 marks)

(b) Fig. 16.1 shows the I-V characteristics of two electrical components **L** and **R**.

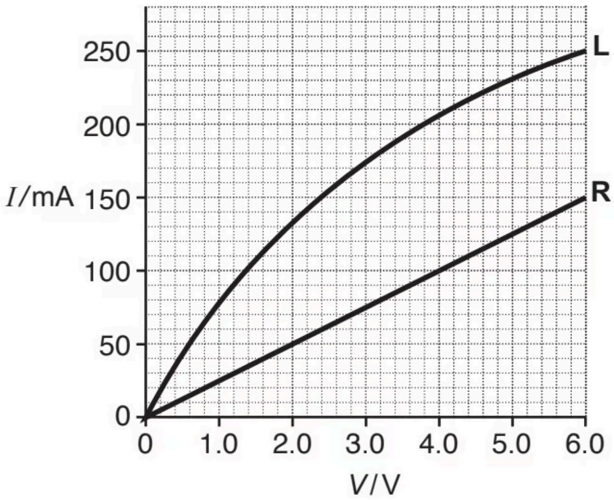


Fig. 16.1

The component **L** is a filament lamp and the component **R** is a resistor.

i) Show that the resistance of **R** is 40Ω.

[1]

ii) Fig. 16.2 shows the components **L** and **R** connected in series to a battery of e.m.f. 6.0 V.

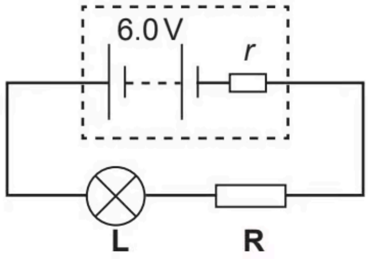


Fig. 16.2

The resistor **R** is a cylindrical rod of length 8.0 mm and cross-sectional area 2.4 × $10^{-6}$$m^2$.

The current in the circuit is 100 mA.

1. Use Fig. 16.1 to determine the internal resistance *r* of the battery.

r = ... Ω **[3]**

2. Calculate the resistivity *ρ* of the material of the resistor **R**.

ρ = ... Ωm **[2]**

3. There are 6.5 × 10^{17} charge carriers within the volume of **R**. Calculate the mean drift velocity *v* of the charge carriers within the resistor **R**.

v = ... ms^{-1} **[3]**

(9 marks)

Hard Questions

1 (a) Fig. 3.1 shows the design of a 'mechanical' torch.

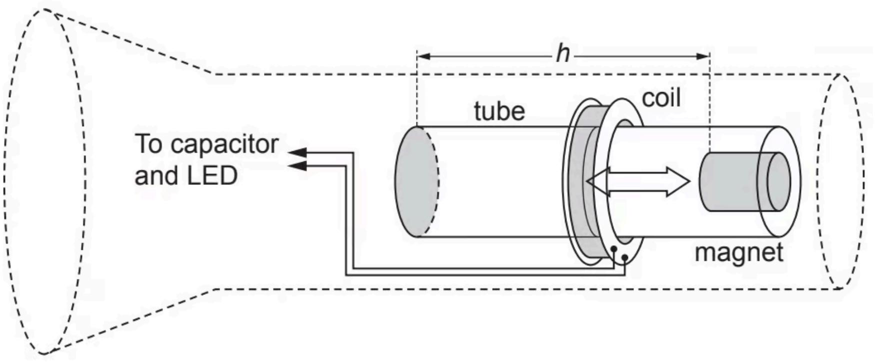


Fig. 3.1

There is no battery in the torch. Instead, when the torch is inverted, the magnet falls a short vertical distance *h* through the coil of wire, as shown in Fig. 3.2. This induces an electromotive force (e.m.f.) across the ends of the coil. The e.m.f. is used to store charge in a capacitor, which lights a light-emitting diode (LED) when it discharges.

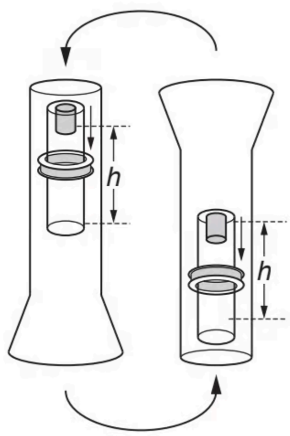


Fig. 3.2

Fig. 3.3 shows the variation with time of the e.m.f. generated as the magnet falls the distance *h*.

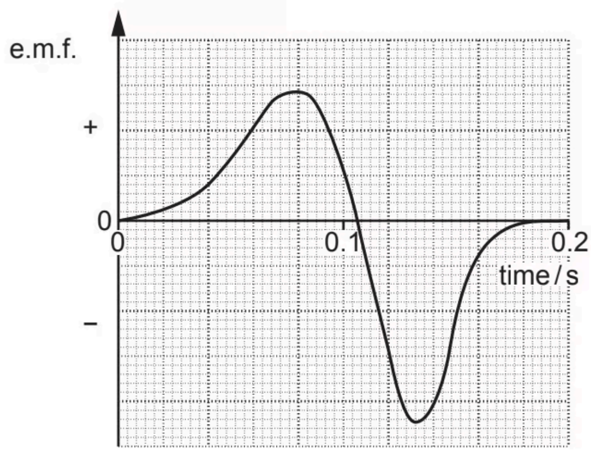


Fig. 3.3

Explain the shape of the curve in Fig. 3.3.

....

....

....

(3 marks)

(b) When the torch is inverted, the pulses of e.m.f. shown in Fig. 3.3 cause a capacitor of capacitance 0.12 F to become charged. Each positive and each negative pulse adds 9.0×10^{-3} C to the charge stored in the capacitor.

i) The torch is inverted 80 times.

Calculate the total energy stored in the capacitor.

total energy = ... J **[3]**

ii) When the torch is switched on, the energy stored in the capacitor lights a 50 mW LED.

Estimate the time for which the LED lights.

time = ... s **[1]**

(4 marks)

(c) In the torch, the gravitational potential energy of the magnet is converted into electrical energy supplied to the 50 mW LED.

You are asked to investigate whether the efficiency of this energy conversion depends on the number of inversions of the torch.

- Describe how you will make accurate measurements to collect your data. Assume that both the torch and the tube can be opened.
- Explain how you will use the data to reach a conclusion.

(6 marks)