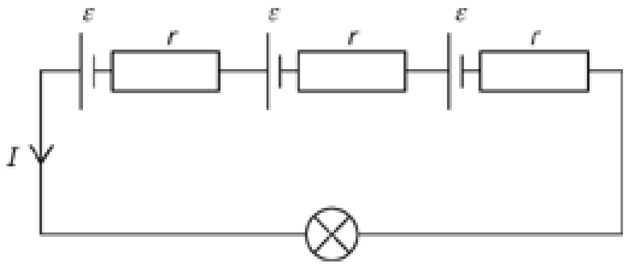
1. A torch uses three identical cells connected in series to a bulb.

Each cell has e.m.f. ε and internal resistance r.



The current in the circuit is I.

Show that the power P delivered to the bulb is given by

$P = 3I(\varepsilon - Ir)$

[3]

2. A thermistor has a resistance that decreases as temperature increases.

A student makes measurements to plot the variation of resistance with temperature of the thermistor.

They submerge the thermistor into distilled water at 50° C.

They then record measurements from a voltmeter and ammeter as the temperature of the water falls to about 20° C.

Describe how the student obtains sufficient data to plot a graph of resistance against temperature.

Your answer should include a circuit diagram.

[4]

3(a). In an experiment a circuit is set up so that a capacitor with a resistor in series can be charged and at some later time discharged through the same resistor without changing the positions of the components. This process can be repeated.

The supply has a potential difference (p.d.) 6.0 V d.c.

The capacitor has capacitance 1.0 μF.

The resistor has resistance 10 kΩ.

A voltmeter is used to measure the p.d. across the capacitor.

Draw a circuit diagram for this experiment.

[2]

(b). Calculate the charge *Q* stored on the capacitor when it is fully charged.

Q = ...C **[1]**

(c). Use a calculation to explain why it will not be possible to measure the variation of p.d. across the capacitor with time, using a stop watch.

____

____ **[4]**

(d). State how this experiment can be modified to measure the variation of p.d. across the capacitor with time as the capacitor charges.

____

____ **[1]**

(e). The capacitor was completely charged and then discharged to 4.12 V.

i. Calculate the time *t* required for the p.d. across the capacitor to reach 4.12 V when discharging.

t = ...s **[2]**

ii. Calculate the average rate at which energy is lost by the capacitor as it discharges from 6.0 V to 4.12 V.

average rate at which energy is lost = ...J s^{-1} **[3]**

4.

The capacitor circuit shown in **Fig. 6.1** can be used to smooth oscillating electrical signals.

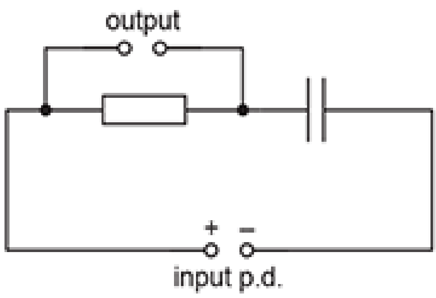


Fig. 6.1

i. **Fig. 6.2** shows the input signal of potential difference (p.d.) *V* against time *t*.

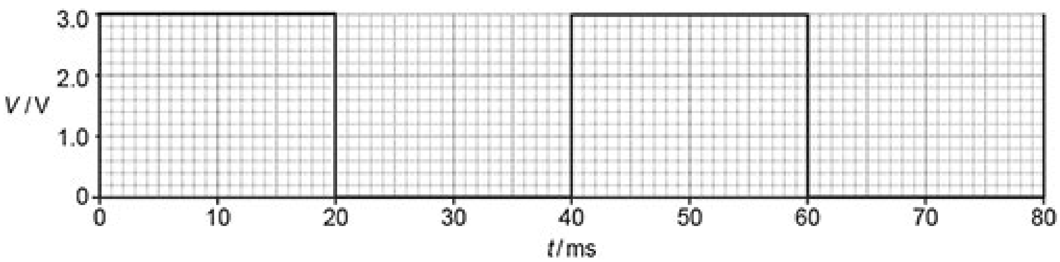


Fig. 6.2

Calculate the frequency *f* of this input signal.

f = ... Hz **[2]**

ii. **Fig. 6.3** shows the variation of the charge *Q* on the positive plate of the capacitor with time *t*.

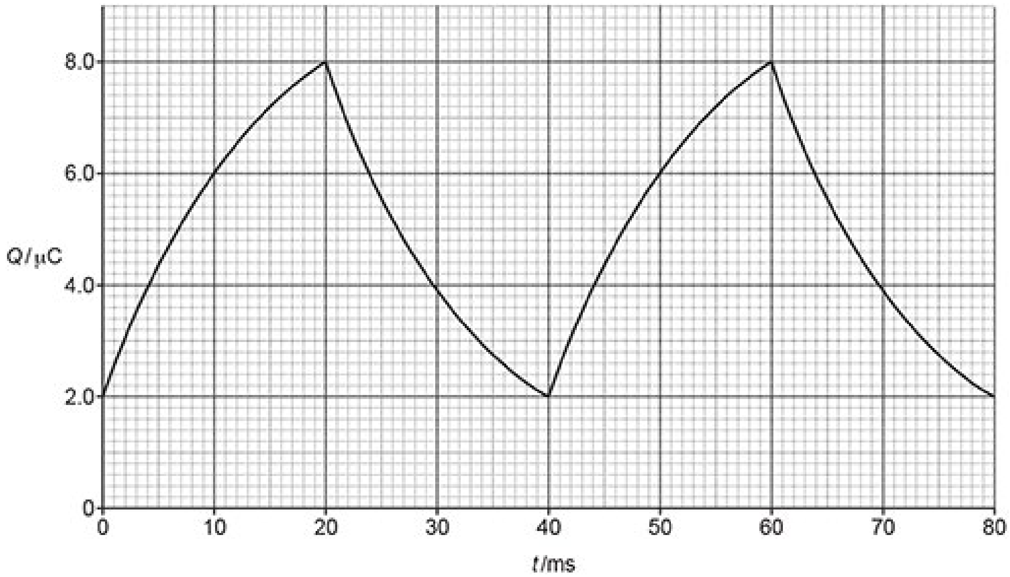


Fig. 6.3

Use a discharging section of the graph in **Fig. 6.3** to determine the time constant of the circuit. Give your answer in ms.

time constant = ... ms **[2]**

iii. By drawing a suitable tangent to the graph in **Fig. 6.3**, calculate the maximum current in the resistor.

maximum current = ...A **[2]**

iv. On **Fig. 6.4** below, sketch the variation of the current *I* in the resistor with time *t*. Include an appropriate label and scale on the vertical axis.

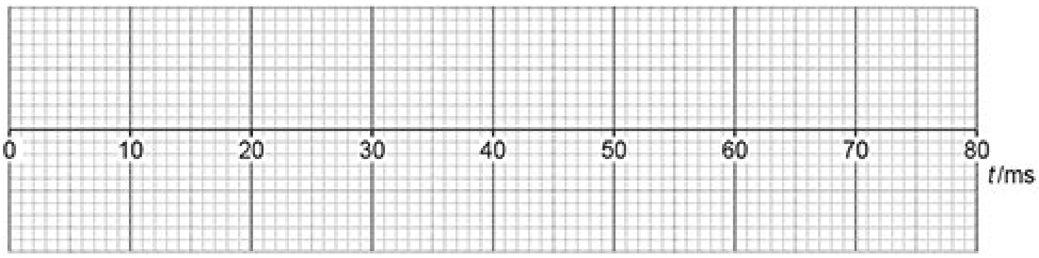


Fig. 6.4

[3]

5.

Fig. 25.1 shows an electrical circuit.

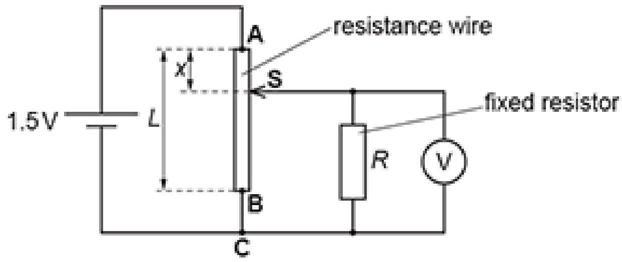


Fig. 25.1

The cell has e.m.f. 1.5 V and negligible internal resistance.

AB is a resistance wire of length L. The resistance of this wire is **equal** to the resistance R of the fixed resistor.
S is a sliding contact that can be moved on the resistance wire. The distance between **A** and **S** is x.
The p.d. across the fixed resistor is V.

i. The distance x is changed by moving the slider from **A** to **B**.

On **Fig. 25.2**, show the variation of V with distance x.

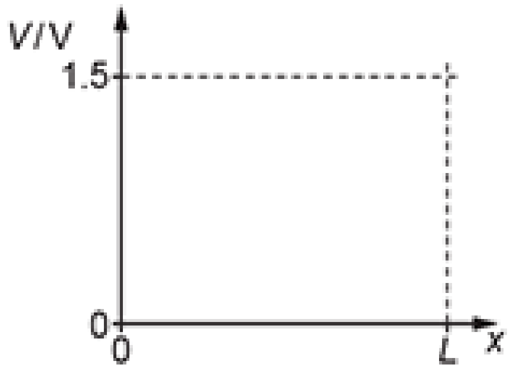


Fig. 25.2

[2]

ii. The connecting wire **BC** is now removed. The rest of the circuit remains unchanged.
Explain the variation of V with distance x as **S** is moved from **A** to **B**.

____

____

____

[2]

6(a). An electric cooker has two independent heating rings **A** and **B** as shown in **Fig. 7.1**.

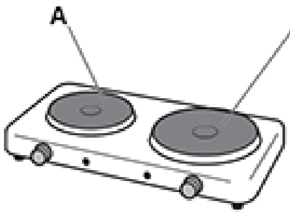


Fig. 7.1

The cooker rings **A** and **B** are connected in parallel to a 230 V power supply. At maximum power, ring **A** has a power of 1100 W and ring **B** has a power of 1700 W.

The filament in ring **A** is a metallic wire of length 11.8 m.
At maximum power the wire has resistance 31 Ω and the metal has resistivity 4.8×10^{-7} Ω m.

Calculate the diameter *d* of the wire.

d = ... m **[3]**

(b). Fig. 7.2 shows the circuit symbol for ring **A**.

Fig. 7.2

A student uses a battery of four cells, an ammeter and a voltmeter to determine the resistance of the wire in ring **A** experimentally.

i. Complete **Fig. 7.2** to show how the student should connect the circuit to determine the resistance.

[2]

ii. The current in the wire is 0.34 ± 0.02 A and the potential difference across the wire is 6.2 ± 0.2 V.

Calculate the resistance *R* of the wire.

R = ... Ω **[1]**

iii. Calculate the percentage uncertainty in *R*.

percentage uncertainty = ... % **[2]**

iv. Suggest why *R* from **(c)(ii)** is less than 31 Ω.

[2]

v. Suggest **two** improvements to the student's experiment to determine *R* experimentally.

1

2

[2]

END OF QUESTION PAPER