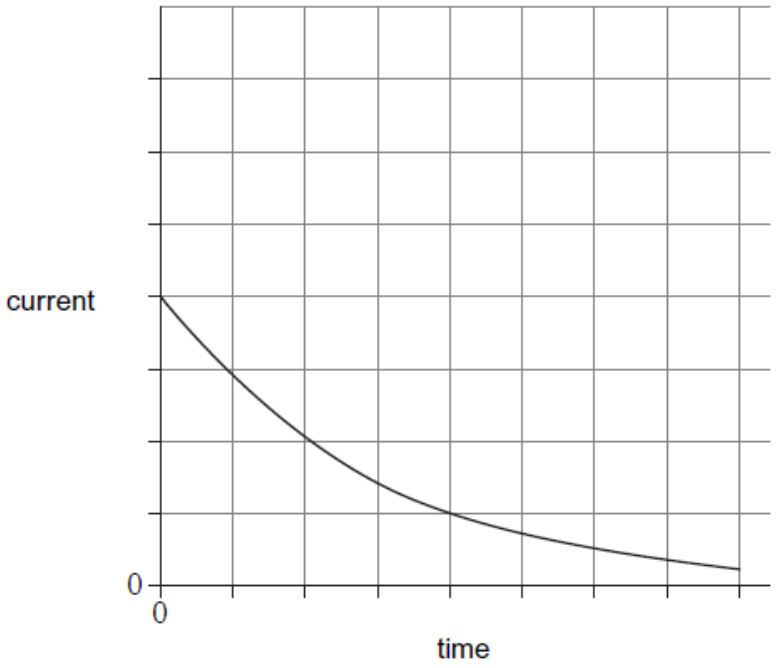
Mixed Exam Questions – Set 9

1.

(a) **Figure 4** shows how the current varies with time as a capacitor is discharged through a 150 Ω resistor.

Figure 4



(a) (i) Explain how the initial charge on the capacitor could be determined from a graph of current against time.

[1 mark]

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(a) (ii) The same capacitor is charged to the same initial potential difference (pd) and then discharged through a 300 kΩ resistor. Sketch a second graph on the same axes above to show how the current varies with time in this case.

[3 marks]

(b) In an experiment to show that a capacitor stores energy, a student charges a capacitor from a battery and then discharges it through a small electric motor. The motor is used to lift a mass vertically.

(b) (i) The capacitance of the capacitor is 0.12 F and it is charged to a pd of 9.0 V.
The weight of the mass raised is 3.5 N.
Calculate the maximum height to which the mass could be raised.
Give your answer to an appropriate number of significant figures.

[4 marks]

maximum height ..... m

(b) (ii) Give **two** reasons why the value you have calculated in part (b)(i) would not be achieved in practice.

[2 marks]

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2 .....

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2.

(a) When an uncharged capacitor is charged by a **constant** current of $4.5\,\mu A$ for $60\,s$ the pd across it becomes $4.4\,V$.

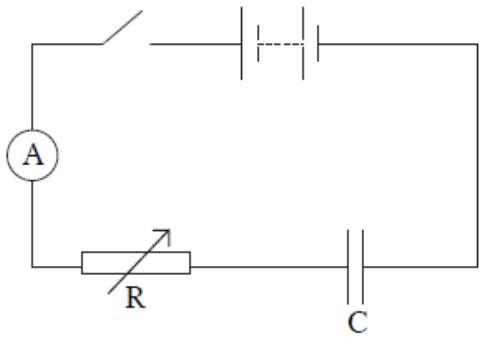
(a) (i) Calculate the capacitance of the capacitor.

[3 marks]

capacitance ..... F

(a) (ii) The capacitor is charged using the circuit shown in **Figure 5**. The battery emf is $6.0\,V$ and its internal resistance is negligible. In order to keep the current constant at $4.5\,\mu A$, the resistance of the variable resistor R is decreased steadily as the charge on the capacitor increases.

Figure 5



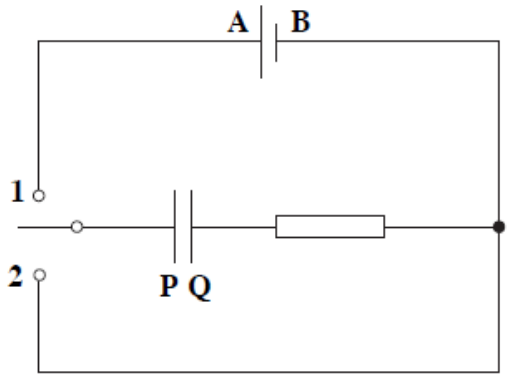
Calculate the resistance of R when the uncharged capacitor has been charging for $30\,s$.

[3 marks]

resistance ..... Ω

(b) The circuit in **Figure 6** contains a cell, an uncharged capacitor, a fixed resistor and a two-way switch.

Figure 6



The switch is moved to position **1** until the capacitor is fully charged. The switch is then moved to position **2**.

Describe what happens in this circuit after the switch is moved to position **1**, and after it has been moved to position **2**. In your answer you should refer to:

- the direction in which electrons flow in the circuit, and how the flow of electrons changes with time,
- how the potential differences across the resistor and the capacitor change with time,
- the energy changes which take place in the circuit.

The terminals of the cell are labelled **A** and **B** and the capacitor plates are labelled **P** and **Q** so that you can refer to them in your answer.

The quality of your written communication will be assessed in your answer.

[6 marks]

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3.

(a)

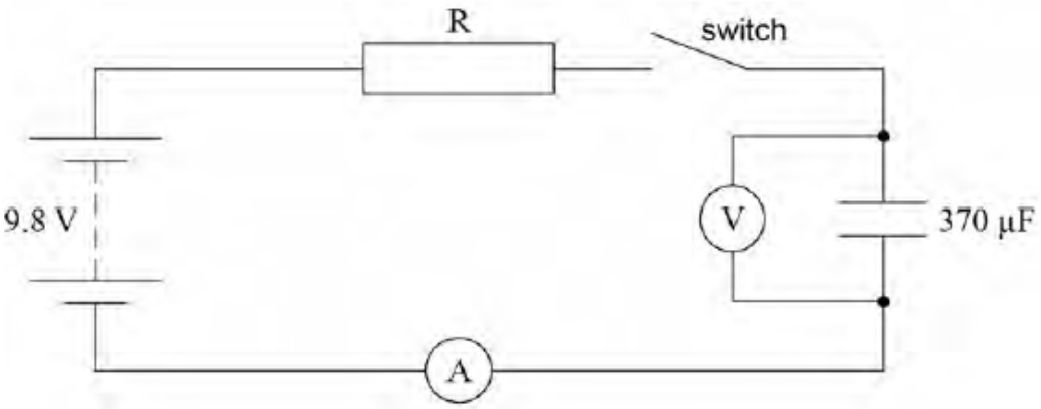
State what is meant by a capacitance of 370 μF

[2 marks]

(b)

The charging of a 370 μF capacitor is investigated using the circuit shown in **Figure 4**. Both meters in the circuit are ideal.

Figure 4



The power supply of emf 9.8 V has a negligible internal resistance. The capacitor is initially uncharged. When the switch is closed at time $t = 0$ charge begins to flow through resistor R. The time constant of the charging circuit is 1.0 s

Calculate the resistance of R.

[1 mark]

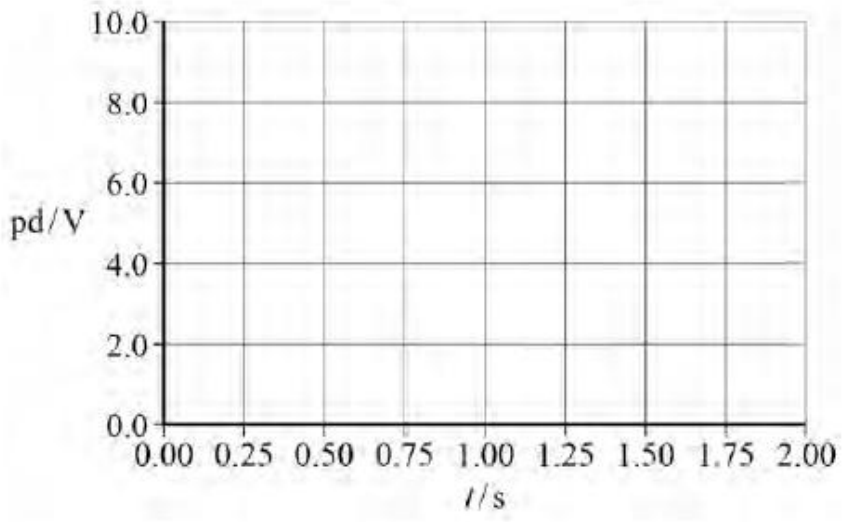
resistance of R = _____ Ω

(c)

Identify, with the symbol X on **Figure 5**, the potential difference (pd) across the capacitor when the switch has been closed for 2.0 s
Sketch the graph that shows how the pd varies from $t = 0$ to $t = 2.0$ s

[2 marks]

Figure 5



(d)

Calculate the time taken for the charging current to fall to half its initial value.

[1 mark]

time = _____ s

(e)

Calculate the time taken for the charge on the capacitor to reach 3.0 mC

[3 marks]

time = _____ s

Question 4 is on the next page.

4.

(a) Define *capacitance*.

.....

..... **[1]**

(b) Fig. 1.1 shows a circuit consisting of a resistor and a capacitor of capacitance 4.5 μF.

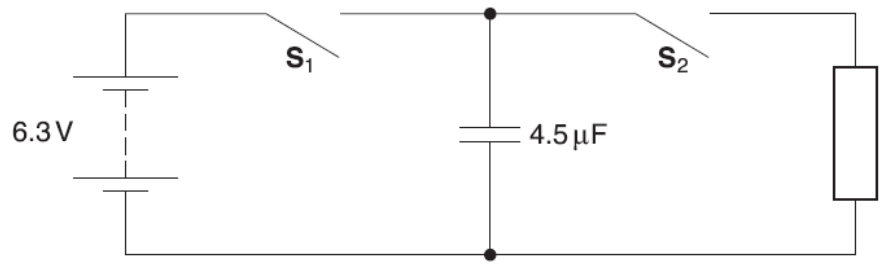


Fig. 1.1

Switch S_1 is closed and switch S_2 is left open. The potential difference across the capacitor is 6.3 V.

Calculate

(i) the charge stored by the capacitor

charge = ... μC **[1]**

(ii) the energy stored by the capacitor.

energy = ... J **[2]**

(c) Switch S_1 is opened and switch S_2 is closed.

(i) Describe and explain in terms of the movement of electrons how the potential difference across the capacitor changes.

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..... **[3]**

(ii) The energy stored in the capacitor decreases to zero. State where the initial energy stored in the capacitor is dissipated.

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..... **[1]**

(d) Fig.1.2 shows the 4.5 μF capacitor now connected in parallel with a capacitor of capacitance 1.5 μF. Both switches are open and both capacitors are uncharged.

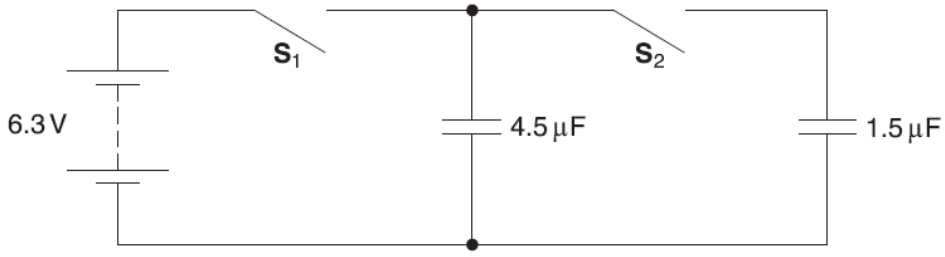

Fig. 1.2

Switch S_1 is closed. The potential difference across the 4.5 μF capacitor is now 6.3 V. Switch S_1 is opened and then switch S_2 is closed.

(i) Calculate the total capacitance of the circuit when S_2 is closed.

capacitance = ... μF **[1]**

(ii) Calculate the final potential difference across the capacitors.

potential difference = ... V **[2]**

5.

(a) Define *capacitance*.

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..... **[1]**

(b) Fig. 2.1 shows two capacitors of capacitance 150 μF and 450 μF connected in series with a battery of e.m.f. 6.0V. The battery has negligible internal resistance.

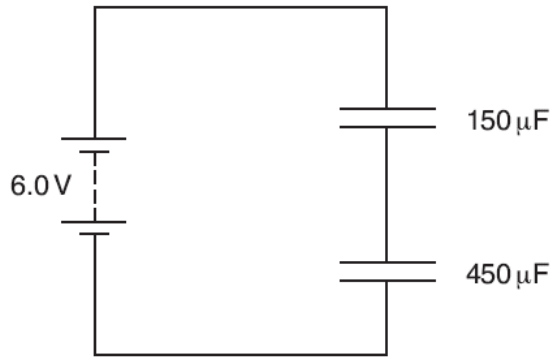

Fig. 2.1

For the circuit shown in Fig. 2.1, calculate

(i) the potential difference across the 150 μF capacitor

potential difference = ... V **[2]**

(ii) the charge stored by the 150 μF capacitor

charge = ... C **[1]**

(iii) the total capacitance of the circuit.

capacitance = ... F **[1]**

(c) The fully charged capacitors shown in **(b)** are disconnected from the battery. The capacitors are then connected in series with a resistor **R** of resistance 45 kΩ and an open switch **S** as shown in Fig. 2.2.

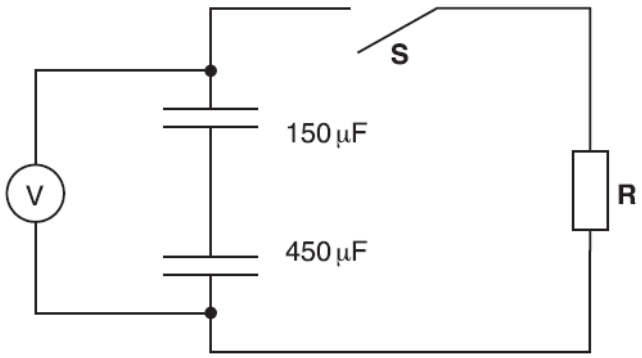

Fig. 2.2

The p.d. *V* across the capacitors is measured with a voltmeter of infinite resistance.
The switch **S** is closed at time $t = 0$ and measurements of *V* are made at regular time intervals.

(i) Show that the time constant for the circuit is about 5 s.

[1]

(ii) On Fig. 2.3 sketch the variation of p.d. *V* with time *t*.

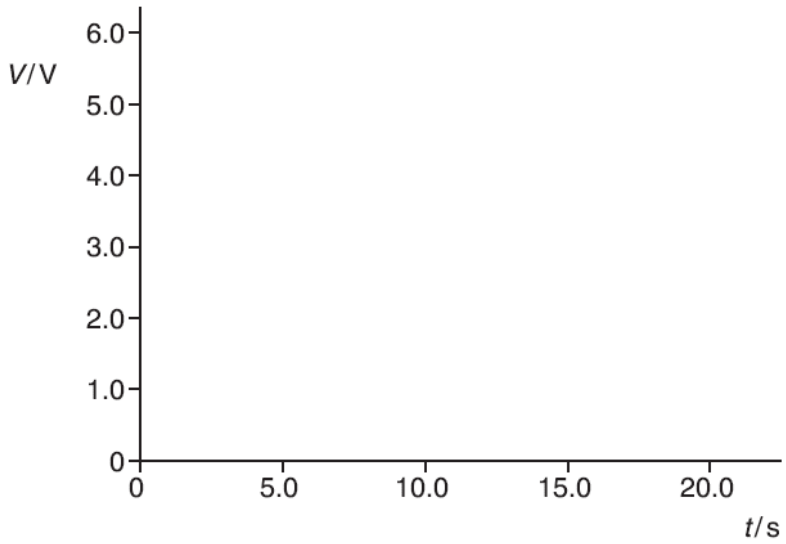

Fig. 2.3

[3]

(iii) At time $t = 0$ calculate the ratio

$$\frac{\text{energy stored by the } 150\,\mu\text{F capacitor}}{\text{energy stored by the } 450\,\mu\text{F capacitor}}.$$

ratio = ... **[2]**

(iv) State and explain how the ratio varies with time.

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..... **[2]**