Capacitors 2

1.

(a) Define *capacitance*.

....

.... **[1]**

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

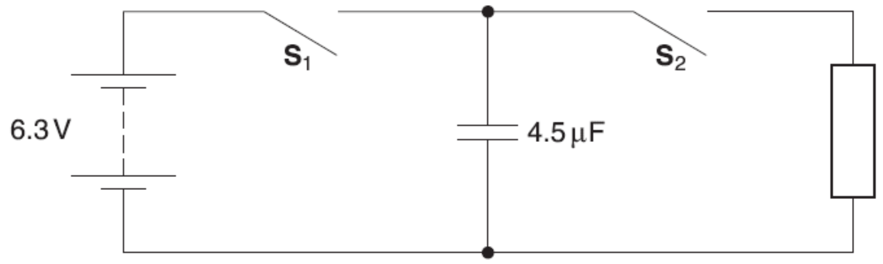

Fig. 1.1

Switch $\mathbf{S_1}$ is closed and switch $\mathbf{S_2}$ 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 $\mathbf{S}_1$ is opened and switch $\mathbf{S}_2$ is closed.

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

....

....

....

.... **[3]**

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

....

.... **[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.

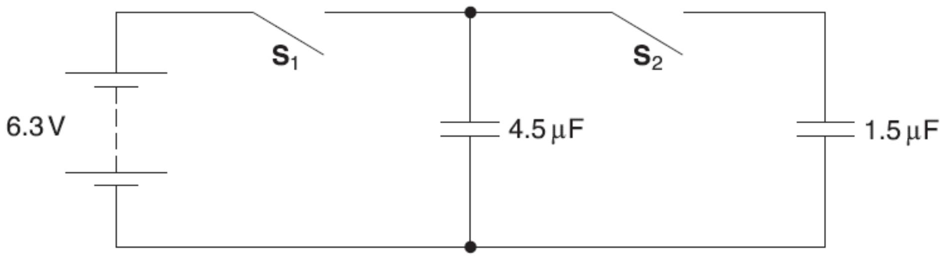

Fig. 1.2

Switch $\mathbf{S}_1$ is closed. The potential difference across the 4.5 μF capacitor is now 6.3 V. Switch $\mathbf{S}_1$ is opened and then switch $\mathbf{S}_2$ is closed.

(i) Calculate the total capacitance of the circuit when $\mathbf{S}_2$ is closed.

capacitance = ... μF **[1]**

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

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

2.

(a) Define *capacitance*.

....

.... **[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. 6.0 V. The battery has negligible internal resistance.

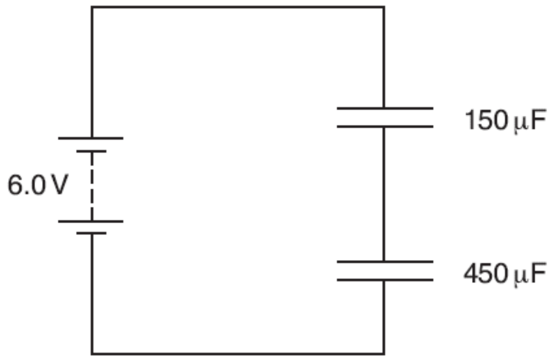

Fig. 2.1

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.

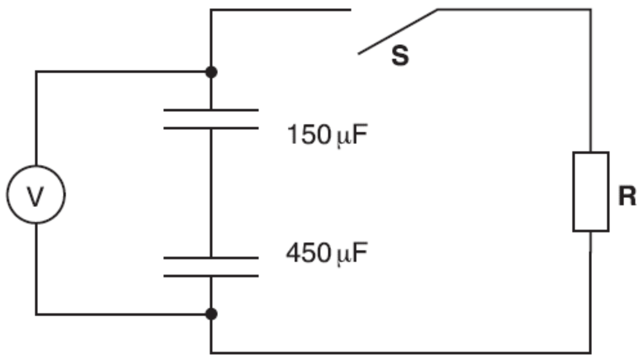

Fig. 2.2

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.

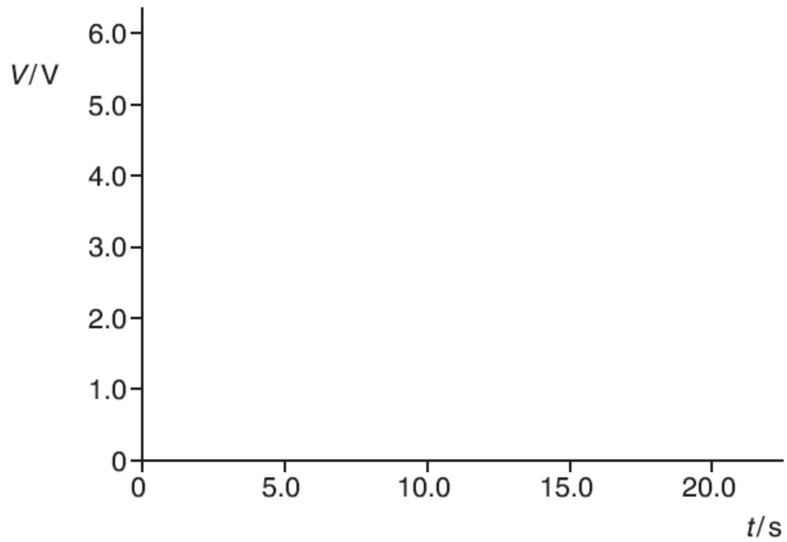

Fig. 2.3

[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.

....

....

.... **[2]**

3.

(a) Define *capacitance*.

....

.... **[1]**

(b) Fig. 4.1 shows an arrangement of three identical capacitors connected to a 6.0 V battery.

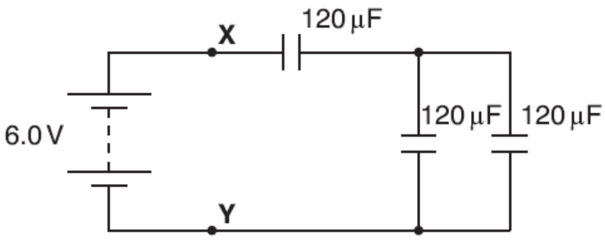

Fig. 4.1

Each capacitor has a capacitance of 120 μF.

(i) Show that the total capacitance of the circuit is 80 μF.

[2]

(ii) Calculate the total energy stored by the capacitors.

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

(iii) The battery is disconnected from the circuit shown in Fig. 4.1. The p.d. between points **X** and **Y** remains at 6.0V. A fixed resistor of resistance R is now connected between **X** and **Y**. Fig. 4.2 shows the variation of the p.d. V across the resistor with time t.

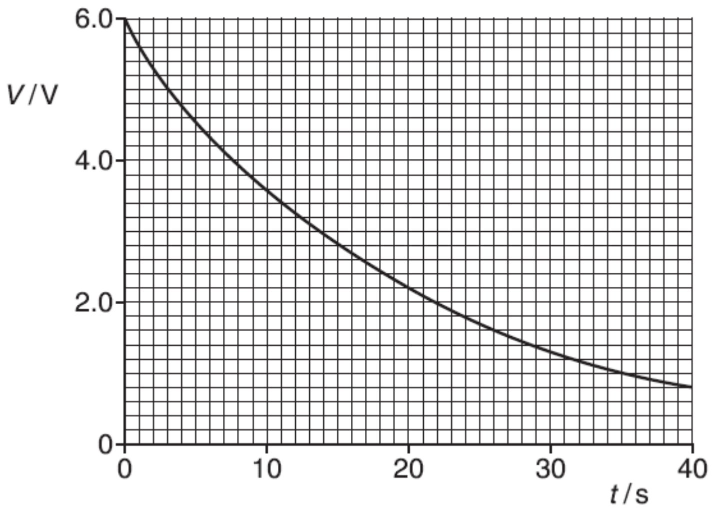

Fig. 4.2

1 Use Fig. 4.2 to show that the circuit has a time constant of 20 s.

[1]

2 Hence, calculate the resistance R of the resistor.

R = ... Ω **[2]**

4.

This question is about charging and discharging a capacitor.

Fig. 4.1 shows a circuit, consisting of two resistors, a capacitor and two milliameters A_1 and A_2, which can be connected to a 12V supply through a switch **S**. Initially, the switch **S** is open and the capacitor is uncharged.

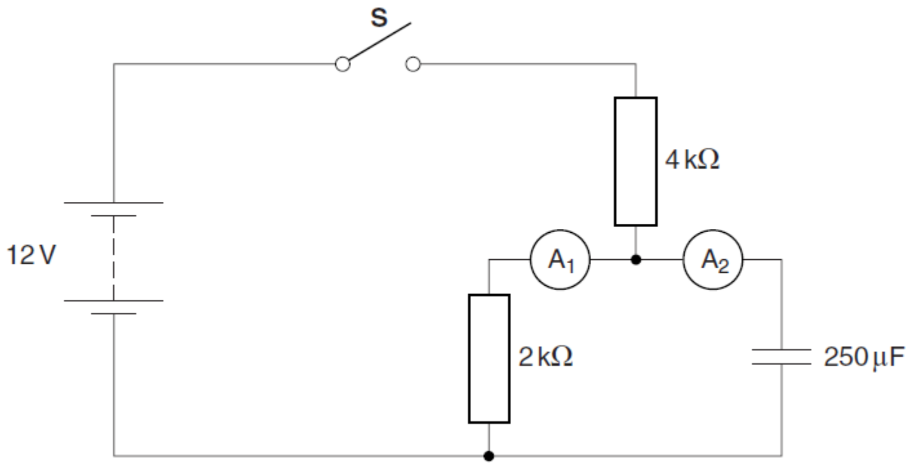

Fig. 4.1

(a) When the switch **S** is closed, explain why the initial current readings are

(i) zero on A_1

....

.... **[2]**

(ii) 3.0 mA on A_2.

....

....

.... **[2]**

(b) After the capacitor has fully charged

(i) state the readings of

1 ammeter A_1 .... mA **[1]**

2 ammeter A_2 .... mA **[1]**

(ii) explain why the voltage across the capacitor is 4.0 V

....

....

.... **[2]**

(iii) calculate the charge Q stored on the capacitor.

Q = ... C **[2]**

(c) The switch **S** is now opened.

(i) State the initial reading of ammeters A_1 and A_2.

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

(ii) Calculate the value of the time constant for the decay of charge on the capacitor.

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

(iii) Plot a graph on the axes of Fig. 4.2 of the reading I of ammeter A_2 from $t = 0$, when the switch is opened, to $t = 1.5$ s. Label the y-axis with a suitable scale. **[3]**

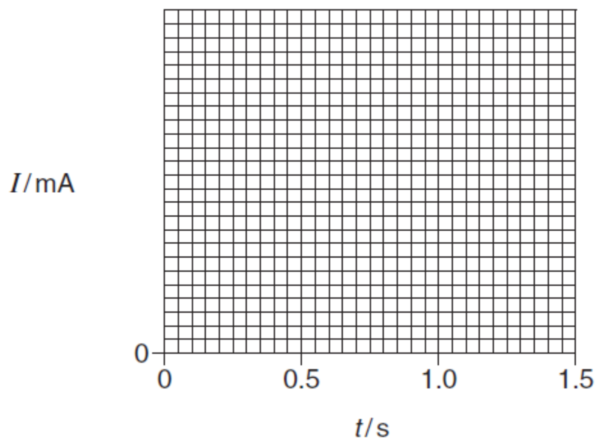

Fig. 4.2