19. Capacitance

19.3 Discharging a capacitor

Paper 4

Question Paper

1 Fig. 6.1 shows a capacitor of capacitance C connected in series with a resistor of resistance R.

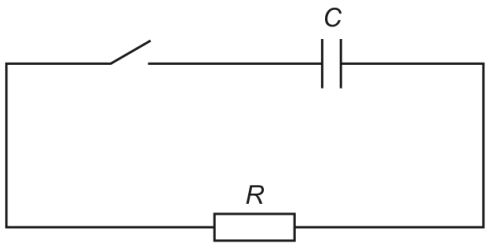


Fig. 6.1

Initially the switch is open and there is a p.d. of 12 V across the capacitor.

At time $t = 0$, the switch is closed so that there is a current I in the resistor.

Fig. 6.2 shows the variation of I with t.

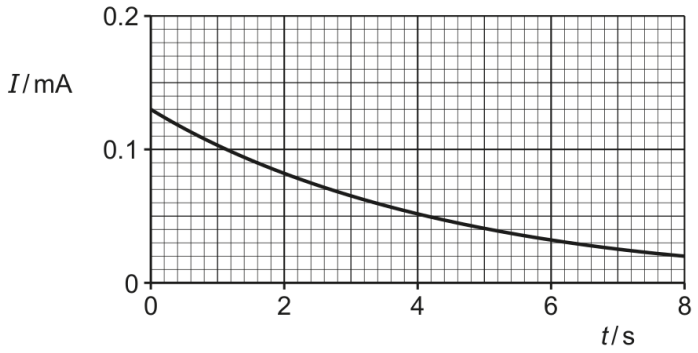


Fig. 6.2

(a) Explain the shape of the line in Fig. 6.2.

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.....

.....

..... [3]

(b) Use Fig. 6.2 to determine:

(i) resistance R

R = ... Ω [2]

(ii) the time constant τ of the circuit in Fig. 6.1.

τ = ... s [3]

(c) Use your answers in **(b)** to determine capacitance *C*.

C = ... F [2]

2 **(c)** The input voltage V_{IN} in Fig. 6.1 is a square wave. Fig. 6.2 shows the variation of V_{IN} with time t.

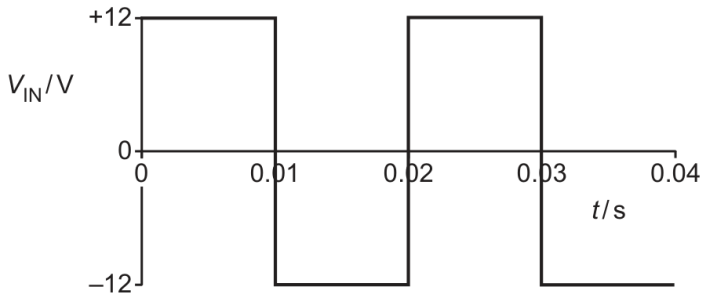


Fig. 6.2

Fig. 6.3 shows the variation of V_{OUT} with t.

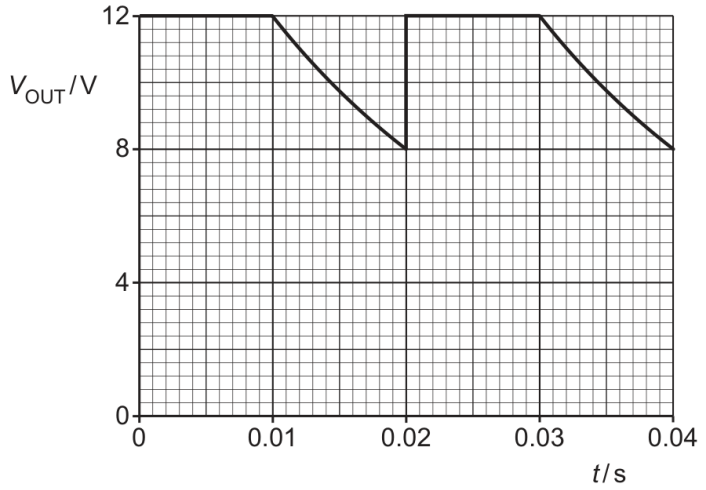


Fig. 6.3

The maximum energy stored in the capacitor is 0.041 J.

(ii) Determine the resistance of R.

resistance = ... Ω [3]

3 Part of an electric circuit is shown in Fig. 5.1.

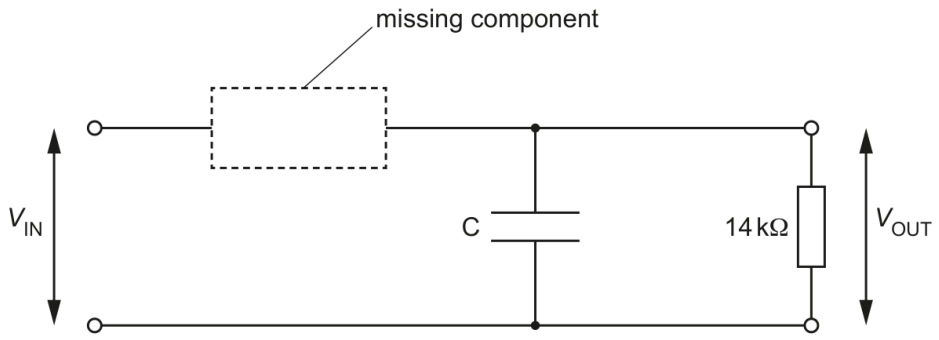


Fig. 5.1

The circuit is used to produce half-wave rectification of an alternating voltage of potential difference (p.d.) V_{IN}.

The output p.d. across the 14 kΩ resistor is V_{OUT}.

(b) Fig. 5.2 shows the variation with time t of V_{IN}.

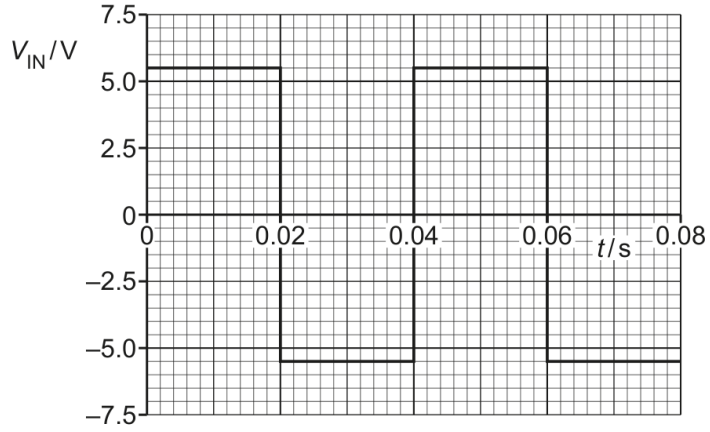


Fig. 5.2

Fig. 5.3 shows the variation with t of V_{OUT}.

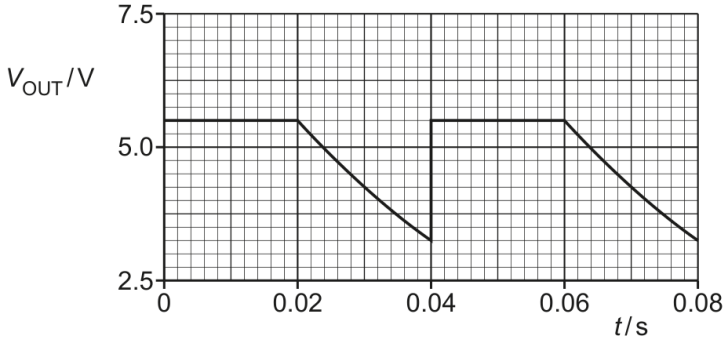


Fig. 5.3

(ii) Show that the time constant τ for the discharge of the capacitor through the resistor is 0.038 s.

[2]

(iii) Calculate the capacitance of C. Give a unit with your answer.

capacitance = ... unit ..... [2]

4 A capacitor C is charged so that the potential difference (p.d.) V across its terminals is 8.0 V. The capacitor is connected into the circuit of Fig. 6.1.

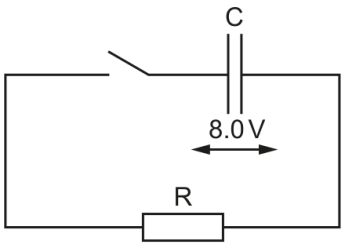


Fig. 6.1

The switch is initially open. The switch is closed at time $t = 0$.

(b) Fig. 6.3 shows the variation with t of $-\ln\left(\frac{V}{8.0\,\text{V}}\right)$.

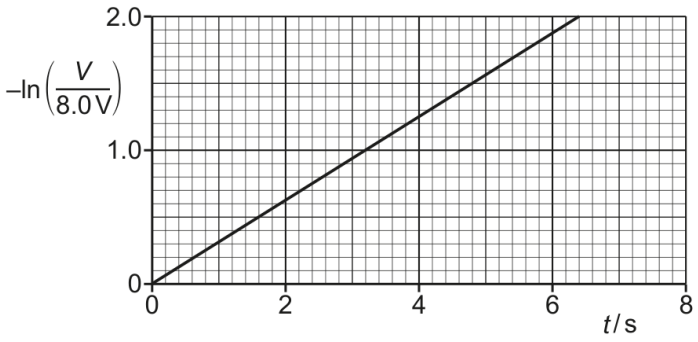


Fig. 6.3

(i) Show that, when t is equal to one time constant, the value of $-\ln\left(\frac{V}{8.0\,\text{V}}\right)$ is equal to 1.0.

[2]

(ii) Determine the time constant τ of the circuit in Fig. 6.1.

τ = ... s [1]

(iii) Calculate the resistance of resistor R.

resistance = ... Ω [2]

5 Fig. 5.1 shows four diodes and a load resistor of resistance 1.2 kΩ, connected in a circuit that is used to produce rectification of an alternating voltage.

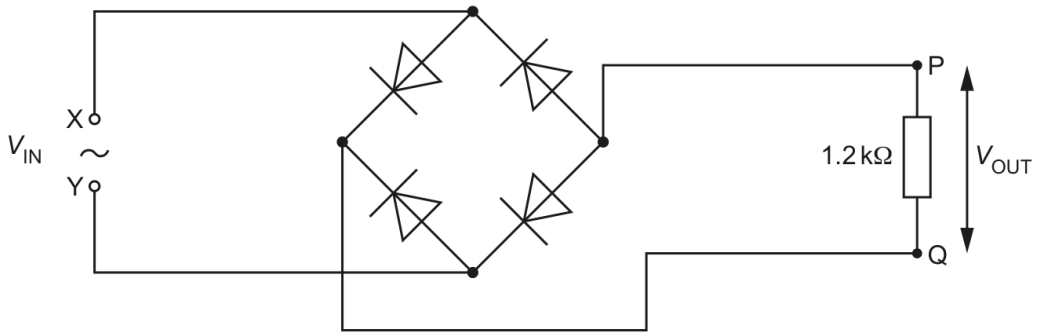


Fig. 5.1

(c) The output voltage in **(b)** is smoothed by adding a capacitor to the circuit in Fig. 5.1.
The difference between the maximum and minimum values of the smoothed output voltage is 10% of the peak voltage.

(iii) Calculate the capacitance *C* of the capacitor.

C = ... F [3]

6 **(c)** Two capacitors of capacitances 22 μF and 47 μF, and a resistor of resistance 2.7 MΩ, are connected into the circuit of Fig. 5.2.

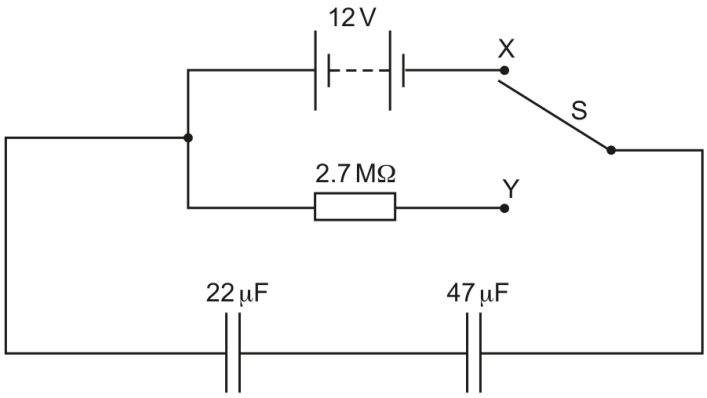


Fig. 5.2

The battery has an e.m.f. of 12 V.

(iii) The two-way switch is now moved to position Y.

Determine the time taken for the potential difference (p.d.) across the 22 μF capacitor to become 6.0 V.

time = ... s [3]

7 A capacitor of capacitance 470 μF is connected to a battery of electromotive force (e.m.f.) 24 V in the circuit of Fig. 5.1.

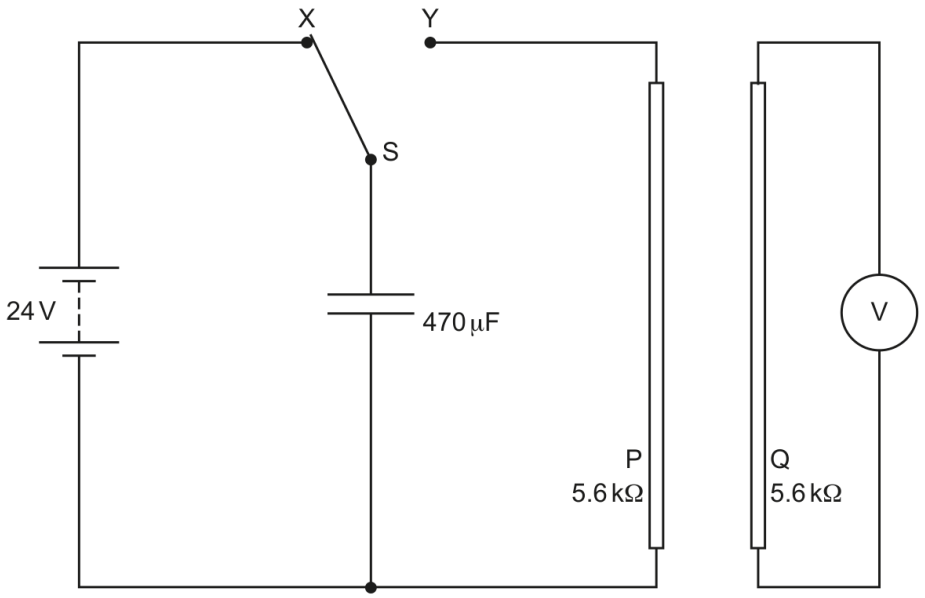


Fig. 5.1

The two-way switch S is initially at position X.

P and Q are identical long straight wires, each with a resistance of 5.6 kΩ. These wires are placed near to, and parallel to, each other. Wire Q is connected to a voltmeter.

At time $t = 0$, switch S is moved to position Y so that the capacitor discharges through wire P.

(a) (ii) Calculate the current I_0 in wire P at time $t = 0$.

I_0 = ... A [1]

(iii) Calculate the time constant τ of the discharge circuit.

τ = ... s [2]

(iv) On Fig. 5.2, sketch a line to show the variation with t of the current I in wire P as the capacitor discharges.



Fig. 5.2

[2]

8 A capacitor of capacitance C and a resistor of resistance R are connected as shown in Fig. 6.1.

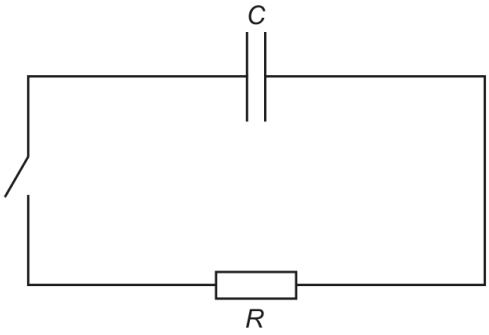


Fig. 6.1

Initially, the capacitor is charged and the switch is open.

The switch is closed at time $t = 0$.

Fig. 6.2 and Fig. 6.3 show, respectively, the variations with t of the charge Q on the capacitor and the potential difference (p.d.) V across the resistor.

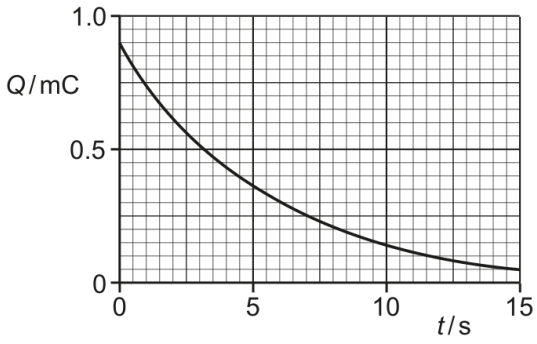


Fig. 6.2

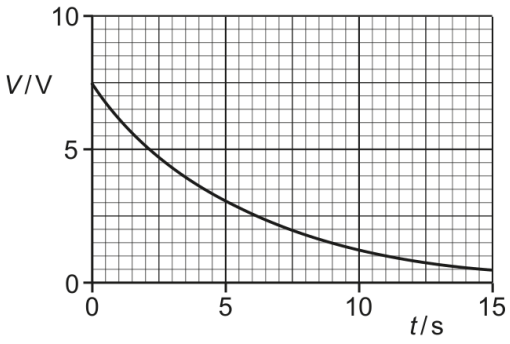


Fig. 6.3

(a) Explain the shape of the line in Fig. 6.3 representing the variation of V with t.

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.....

.....

..... [3]

(b) Use Fig. 6.2 to show that the time constant of the circuit in Fig. 6.1 is 5.5 s.

[3]

(c) Use Fig. 6.2, Fig. 6.3 and the information in **(b)** to determine:

(ii) resistance R, in kΩ.

R = ... kΩ [2]