19. Capacitance

19.2 Energy stored in a capacitor

Paper 4

Question Paper

1 **(b)** Two capacitors P and Q are connected in parallel to a power supply of voltage V.
The capacitance of P is 200 μF. The capacitance C_Q of Q can be varied between 0 and 400 μF.
When C_Q = 0, the total energy stored in the capacitors is 2.5 mJ.

(i) Show that the supply voltage V is 5.0 V.

[2]

(ii) Calculate the total energy, in mJ, stored in the capacitors when C_Q has its maximum value.

total energy = ... mJ [3]

(iii) On Fig. 6.2, sketch the variation of the total energy E stored in the capacitors with C_Q, as C_Q varies from 0 to 400 μF.

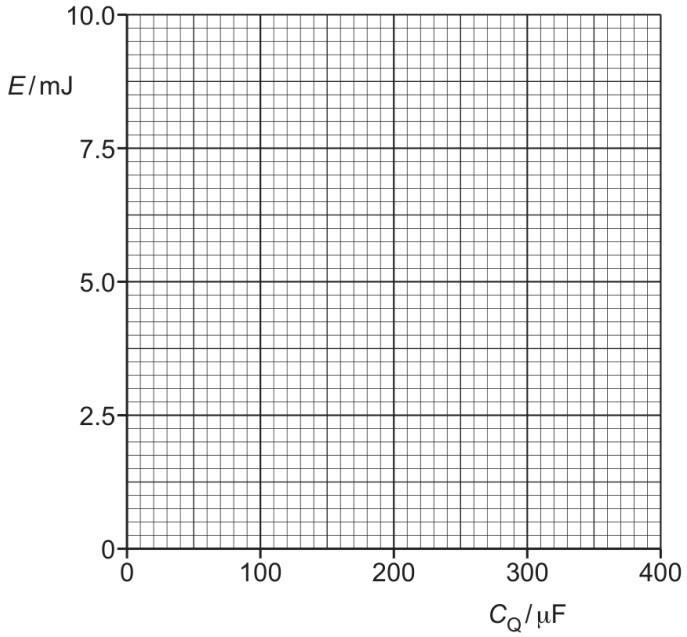


Fig. 6.2

[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.

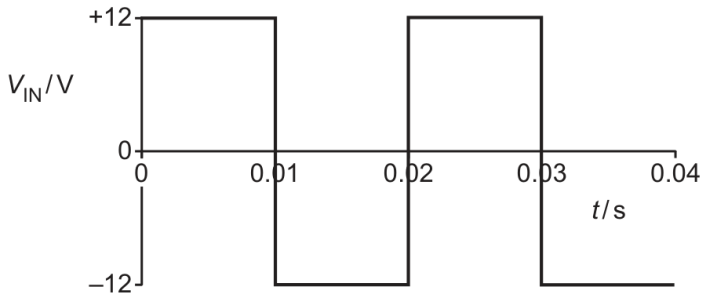


Fig. 6.2

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

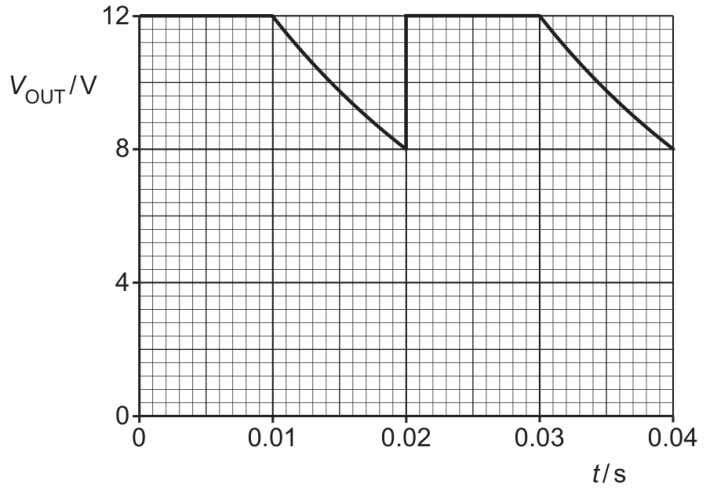


Fig. 6.3

The maximum energy stored in the capacitor is 0.041 J.

(i) Show that the capacitance of C is 570 μF.

[2]

3 **(b)** An initially uncharged capacitor X, of capacitance C, is gradually charged so that the final potential difference (p.d.) between its plates is V and the final charge is Q.

(ii) Determine an expression, in terms of Q and V, for the work W done on capacitor X during the charging process. Explain your reasoning.

W = ... [2]

(c) Another capacitor Y is initially uncharged. The fully charged capacitor X in **(b)** is now connected to capacitor Y, as shown in Fig. 7.2.

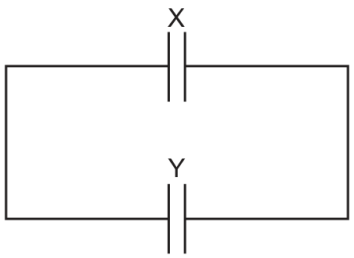


Fig. 7.2

The capacitance of capacitor Y is $3C$.

(ii) State whether the total energy stored in the two capacitors is less than, the same as, or greater than the energy initially stored in capacitor X.

..... [1]

4 Two capacitors A and B are connected into the circuit shown in Fig. 5.1.

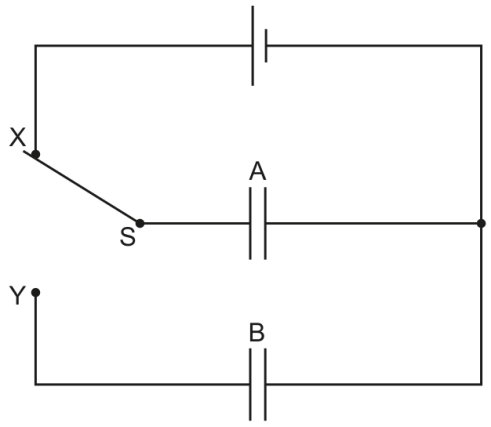


Fig. 5.1

Capacitor A has capacitance C and capacitor B has capacitance $3C$.
The electromotive force (e.m.f.) of the cell is V.
The two-way switch S is initially at position X, and capacitor B is initially uncharged.

(a) State, in terms of V and C, expressions for:

(ii) the initial energy E_A stored in capacitor A.

E_A = ... [1]

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

(iii) Determine an expression, in terms of V and C, for the decrease ΔE in the total energy that is stored in the capacitors as a result of the change of the position of the switch.

ΔE = ... [2]

5 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.

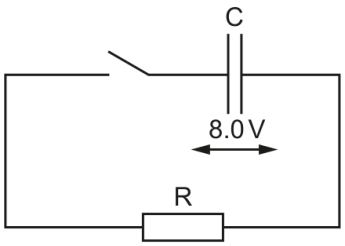


Fig. 6.1

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

(a) Fig. 6.2 shows the variation of V with the charge Q on the plates of capacitor C as the capacitor discharges.

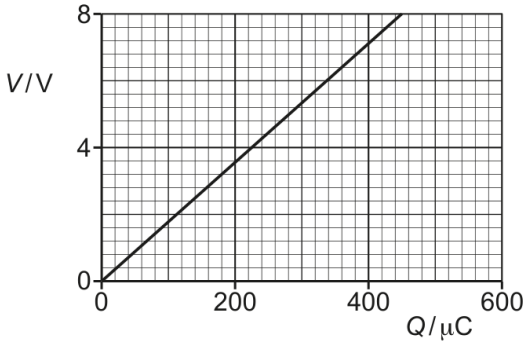


Fig. 6.2

(i) Show that the energy stored in capacitor C at time $t = 0$ is 1.8 mJ.

[2]

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.

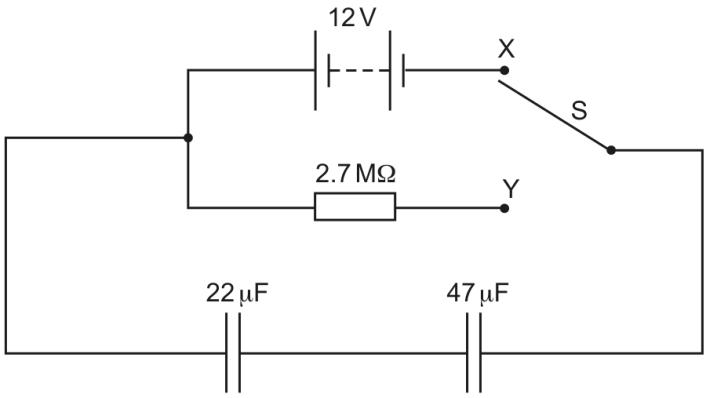


Fig. 5.2

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

(ii) The two-way switch S is initially at position X, so that the capacitors are fully charged.

Use the information in **(c)(i)** to calculate the total energy stored in the two capacitors.

total energy = ... J [2]

7 **(c)** Explain whether reducing the separation of the plates in **(b)** results in an increase or decrease in the energy stored in the capacitor.

.....

.....

..... [1]

8 **(c)** Two capacitors of capacitances 3.0 μF and 2.0 μF are connected in series with a battery of electromotive force (e.m.f.) 8.0 V, as shown in Fig. 6.1.

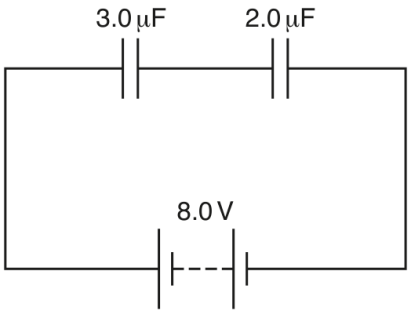


Fig. 6.1

(ii) Use your answer in **(i)** to determine, for the capacitor of capacitance 3.0 μF,

1. the charge on one plate of the capacitor,

charge = ... μC

2. the energy stored in the capacitor.

energy = ... J

[4]