6 **(a)** Two parallel plate capacitors C_1 and C_2 are connected to a supply that has a potential difference (p.d.) V_S. The capacitors may be connected in series or in parallel.

The supply provides charge Q_S and the plates of the two capacitors acquire charges Q_1 and Q_2 respectively. The p.d.s across the plates of the capacitors are V_1 and V_2 respectively.

Complete Table 6.1 to indicate how Q_S, Q_1 and Q_2 relate to each other, and how V_S, V_1 and V_2 relate to each other, for series and parallel connections of the capacitors to the supply.

Table 6.1

	relationship between charges	relationship between p.d.s
series		
parallel		

[4]

(b) An isolated capacitor of capacitance 470 μF stores 19 mJ of energy.

(i) Calculate the p.d. across the capacitor.

p.d. = ... V [2]

(ii) Calculate the charge on the capacitor.

charge = ... C [2]

(iii) The capacitor is now connected in parallel with a capacitor of capacitance 180 μF that is initially uncharged.

Determine the total energy, in mJ, now stored in the two capacitors.

energy = ... mJ [3]

[Total: 11]

5 **(a)** A capacitor of capacitance C_1 is connected in series with a second capacitor of capacitance C_2.

Show that the combined capacitance C of the two capacitors is given by

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}.$$

[2]

(b) Three identical capacitors, each of capacitance C, are connected in a network as shown in Fig. 5.1.

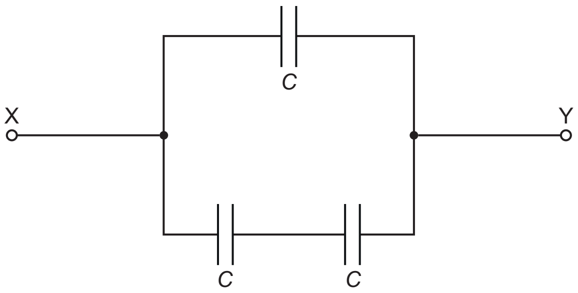

Fig. 5.1

The variation of the charge Q with the potential difference (p.d.) V between the terminals X and Y is shown in Fig. 5.2.

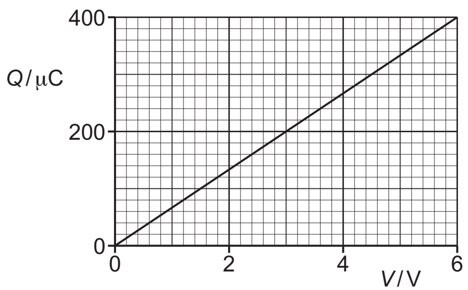

Fig. 5.2

Show that C is equal to 44 μF.

[3]

(c) The capacitor network in Fig. 5.1 is charged and then connected to a resistor of resistance 54 kΩ. The capacitor network discharges through the resistor.

(i) Determine the time constant τ of the circuit. Give a unit with your answer.

τ = ... unit .... [2]

(ii) Determine the time taken for the discharge current to reduce to 15% of the initial discharge current.

time = ... s [2]

[Total: 9]

7 **(a)** Define the capacitance of a parallel-plate capacitor.

....

....

.... [2]

(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.

(i) On Fig. 7.1, sketch the variation of charge with p.d. for capacitor X as the p.d. increases from 0 to V.

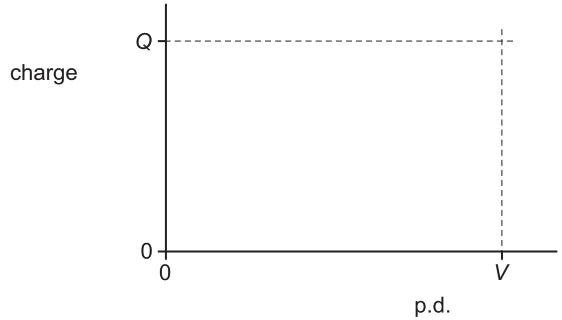

Fig. 7.1

[2]

(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.

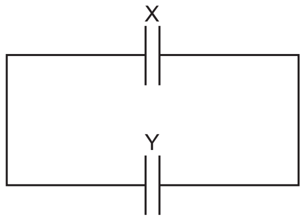

Fig. 7.2

The capacitance of capacitor Y is 3C.

(i) Complete Table 7.1 to show expressions, in terms of Q and V, for the final p.d.s across, and the final charges on, the two capacitors.
Use the space below for any working that you need.

Table 7.1

	X	Y
final p.d.		
final charge		

[3]

(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]

[Total: 10]

6 **(a)** Two capacitors X and Y are connected in series to a power supply of voltage V, as shown in Fig. 6.1.

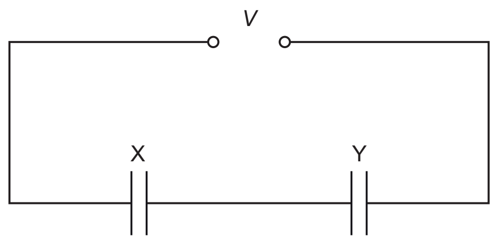

Fig. 6.1

The capacitance of X is C_X and the capacitance of Y is C_Y.

Derive an expression, in terms of C_X and C_Y, for the combined capacitance C_T of the capacitors in this circuit.
Explain your reasoning.

[3]

(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.

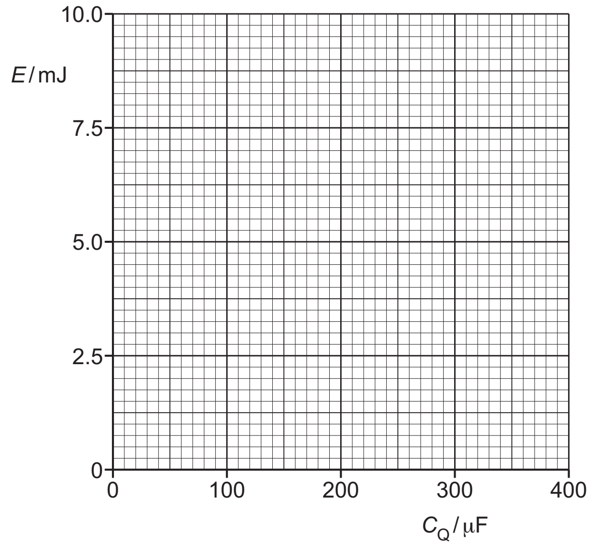

Fig. 6.2

[2]

[Total: 10]