Capacitance

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Capacitance
Sub Topic	
Paper Type	Theory
Booklet	Question paper 1

Time Allowed: **83 minutes**

Score: **/69**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Three capacitors, each of capacitance 48 μF, are connected as shown in Fig. 6.1.

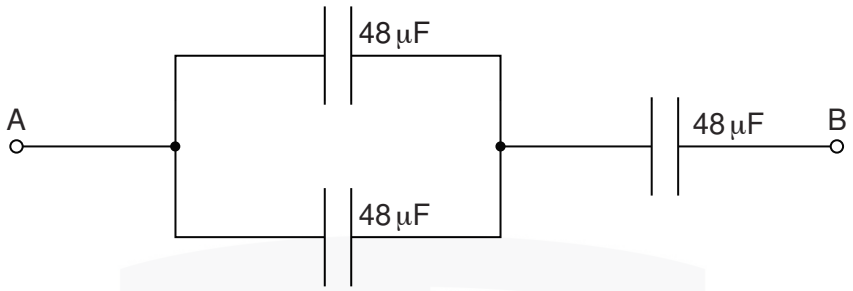

Fig. 6.1

(a) Calculate the total capacitance between points A and B.

capacitance = ... μF [2]

(b) The maximum safe potential difference that can be applied across any one capacitor is 6 V.

Determine the maximum safe potential difference that can be applied between points A and B.

potential difference = ... V [2]

2 An uncharged capacitor is connected in series with a battery, a switch and a resistor, as shown in Fig. 6.1.

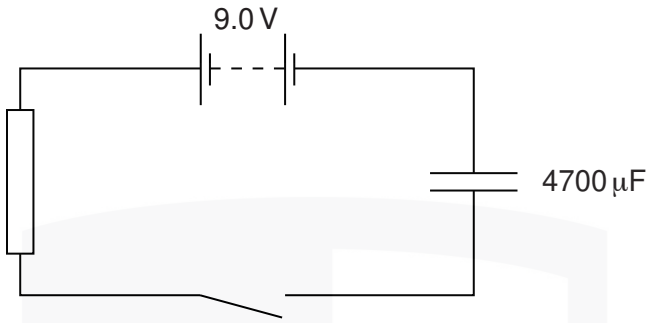

Fig. 6.1

The battery has e.m.f. 9.0 V and negligible internal resistance. The capacitance of the capacitor is 4700 μF.
The switch is closed at time $t = 0$.
During the time interval $t = 0$ to $t = 4.0$ s, the charge passing through the resistor is 22 mC.

(a) (i) Calculate the energy transfer in the battery during the time interval $t = 0$ to $t = 4.0$ s.

energy transfer = ... J [2]

(ii) Determine, for the capacitor at time $t = 4.0$ s,

1. the potential difference V across the capacitor,

V = ... V [2]

2. the energy stored in the capacitor.

energy = ... J [2]

(b) Suggest why your answers in **(a)(i)** and **(a)(ii) part 2** are different.

.....

..... [1]

3 **(a)** State two functions of capacitors connected in electrical circuits.

1. .....

.....

2. .....

.....

[2]

(b) Three capacitors are connected in parallel to a power supply as shown in Fig. 4.1.

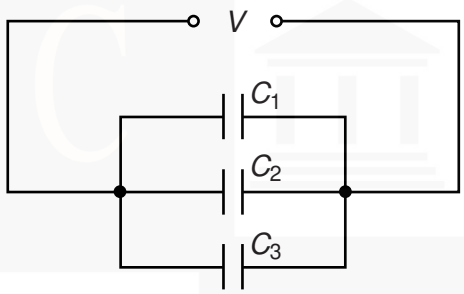

Fig. 4.1

The capacitors have capacitances C_1, C_2 and C_3. The power supply provides a potential difference V.

(i) Explain why the charge on the positive plate of each capacitor is different.

.....

.....

.....[1]

(ii) Use your answer in **(i)** to show that the combined capacitance C of the three capacitors is given by the expression

$$C = C_1 + C_2 + C_3.$$

[2]

(c) A student has available three capacitors, each of capacitance 12 μF.
Draw circuit diagrams, one in each case, to show how the student connects the three capacitors to provide a combined capacitance of

(i) 8 μF,

[1]

(ii) 18 μF.

[1]

4 (a) (i) Define *capacitance*.

.....

.....[1]

(ii) A capacitor is made of two metal plates, insulated from one another, as shown in Fig. 5.1.

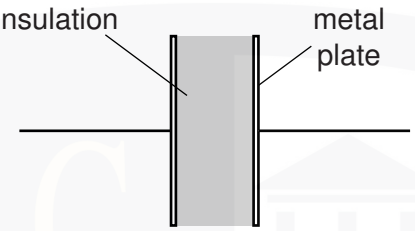

Fig. 5.1

Explain why the capacitor is said to store energy but not charge.

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.....

.....

.....

.....[4]

(b) Three uncharged capacitors X, Y and Z, each of capacitance 12 μF, are connected as shown in Fig. 5.2.

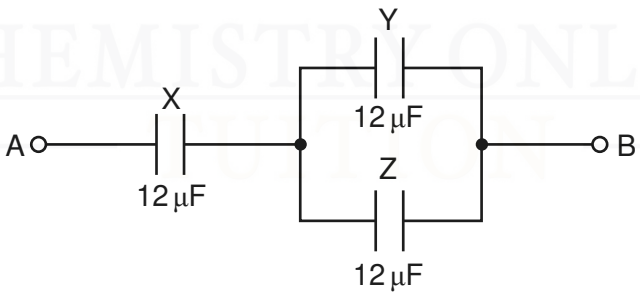

Fig. 5.2

A potential difference of 9.0 V is applied between points A and B.

(i) Calculate the combined capacitance of the capacitors X, Y and Z.

capacitance = ... μF [2]

(ii) Explain why, when the potential difference of 9.0 V is applied, the charge on one plate of capacitor X is 72 μC.

.....

.....

.....[2]

(iii) Determine

1. the potential difference across capacitor X,

potential difference = ... V [1]

2. the charge on one plate of capacitor Y.

charge = ... μC [2]

5 **(a)** State two functions of capacitors in electrical circuits.

1. .....

.....

2. .....

.....

[2]

(b) Three uncharged capacitors of capacitance C_1, C_2 and C_3 are connected in series, as shown in Fig. 4.1.

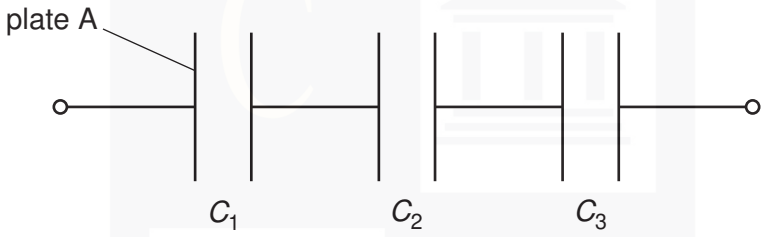

Fig. 4.1

A charge of $+Q$ is put on plate A of the capacitor of capacitance C_1.

(i) State and explain the charges that will be observed on the other plates of the capacitors.
You may draw on Fig. 4.1 if you wish.

.....

.....

..... [2]

(ii) Use your answer in **(i)** to derive an expression for the combined capacitance of the capacitors.

[2]

(c) A capacitor of capacitance 12 μF is charged using a battery of e.m.f. 9.0 V, as shown in Fig. 4.2.

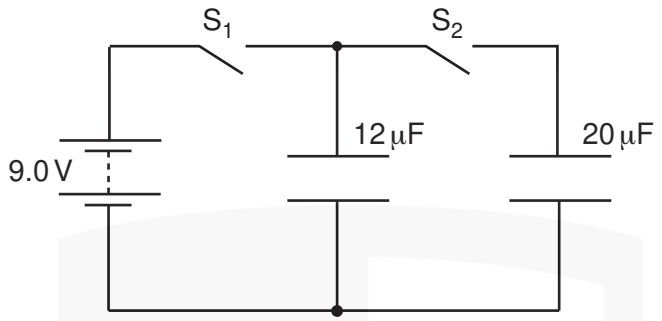

Fig. 4.2

Switch S_1 is closed and switch S_2 is open.

(i) The capacitor is now disconnected from the battery by opening S_1.
Calculate the energy stored in the capacitor.

energy = ... J [2]

(ii) The 12 μF capacitor is now connected to an uncharged capacitor of capacitance 20 μF by closing S_2. Switch S_1 remains open.
The total energy now stored in the two capacitors is 1.82×10^{-4} J.

Suggest why this value is different from your answer in **(i).**

.....

..... [1]

6 A capacitor consists of two metal plates separated by an insulator, as shown in Fig. 3.1.

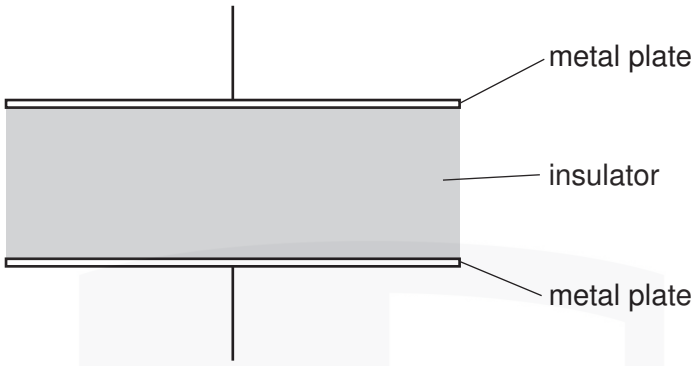

Fig. 3.1

The potential difference between the plates is V. The variation with V of the magnitude of the charge Q on one plate is shown in Fig. 3.2.

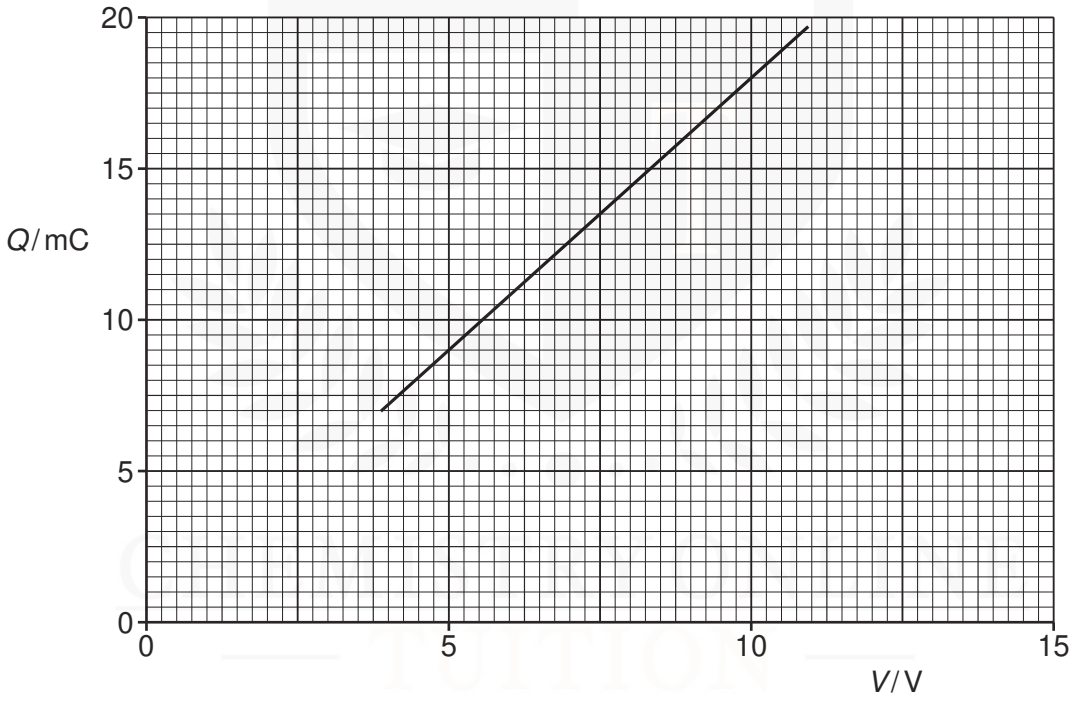

Fig. 3.2

(a) Explain why the capacitor stores energy but not charge.

.....

.....

.....

..... [3]

(b) Use Fig. 3.2 to determine

(i) the capacitance of the capacitor,

capacitance = ... μF [2]

(ii) the loss in energy stored in the capacitor when the potential difference V is reduced from 10.0 V to 7.5 V.

energy = ... mJ [2]

(c) Three capacitors X, Y and Z, each of capacitance 10 μF, are connected as shown in Fig. 3.3.

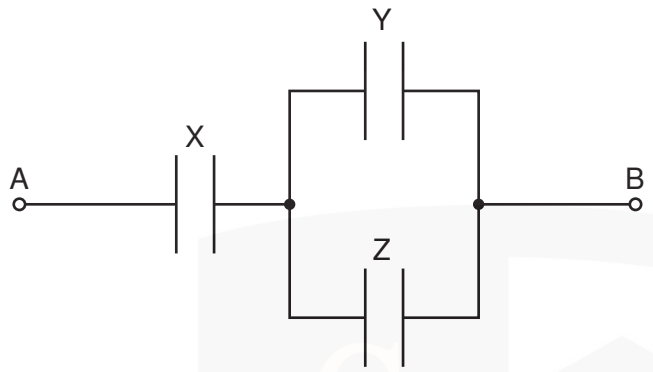

Fig. 3.3

Initially, the capacitors are uncharged.
A potential difference of 12 V is applied between points A and B.
Determine the magnitude of the charge on one plate of capacitor X.

charge = ... μC [3]

7 **(a)** Define *capacitance*.

.....

.....[1]

(b) An isolated metal sphere has a radius r. When charged to a potential V, the charge on the sphere is q.
The charge may be considered to act as a point charge at the centre of the sphere.

(i) State an expression, in terms of r and q, for the potential V of the sphere.

.....[1]

(ii) This isolated sphere has capacitance. Use your answers in **(a)** and **(b)(i)** to show that the capacitance of the sphere is proportional to its radius.

[1]

(c) The sphere in **(b)** has a capacitance of 6.8 pF and is charged to a potential of 220 V.

Calculate

(i) the radius of the sphere,

radius = ... m [3]

(ii) the charge, in coulomb, on the sphere.

charge = ... C [1]

(d) A second uncharged metal sphere is brought up to the sphere in **(c)** so that they touch. The combined capacitance of the two spheres is 18 pF.

Calculate

(i) the potential of the two spheres,

potential = ... V [1]

(ii) the change in the total energy stored on the spheres when they touch.

change = ... J [3]

8 **(a)** **(i)** State what is meant by *electric potential* at a point.

.....

.....

..... [2]

(ii) Define *capacitance*.

.....

..... [1]

(b) The variation of the potential V of an isolated metal sphere with charge Q on its surface is shown in Fig. 4.1.

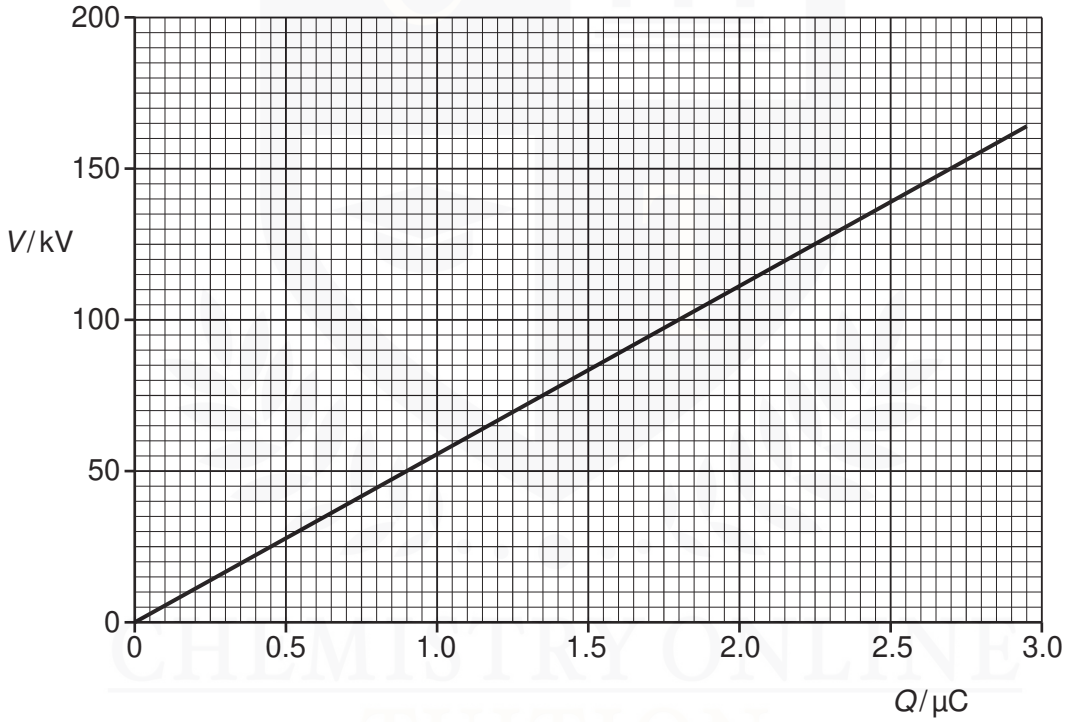

Fig. 4.1

An isolated metal sphere has capacitance. Use Fig. 4.1 to determine

(i) the capacitance of the sphere,

capacitance = ... F [2]

(ii) the electric potential energy stored on the sphere when charged to a potential of 150 kV.

energy = ... J [2]

(c) A spark reduces the potential of the sphere from 150 kV to 75 kV.
Calculate the energy lost from the sphere.

energy = ... J [2]