Capacitance

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Capacitance
Sub Topic	
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **88 minutes**

Score: **/73**

Percentage: **/100**

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

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

1. .....

2. .....

[2]

(b) Three capacitors, each marked '30 μF, 6 V max', are arranged as shown in Fig. 5.1.

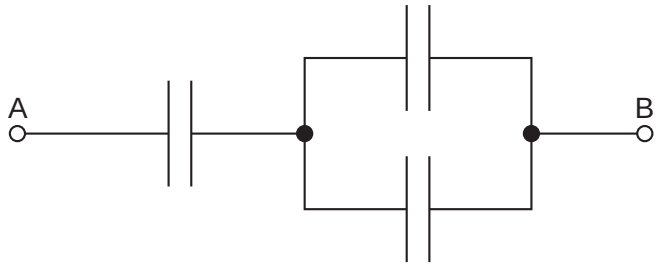

Fig. 5.1

Determine, for the arrangement shown in Fig. 5.1,

(i) the total capacitance,

capacitance = ... μF [2]

(ii) the maximum potential difference that can safely be applied between points A and B.

potential difference = ... V [2]

(c) A capacitor of capacitance 4700 μF is charged to a potential difference of 18 V. It is then partially discharged through a resistor. The potential difference is reduced to 12 V. Calculate the energy dissipated in the resistor during the discharge.

energy = ... J [3]

2 **(a)** Define *capacitance*.

.....

..... [1]

(b) An isolated metal sphere of radius R has a charge $+Q$ on it.

The charge may be considered to act as a point charge at the centre of the sphere.

Show that the capacitance C of the sphere is given by the expression

$$C = 4\pi\varepsilon_0 R$$

where ε_0 is the permittivity of free space.

[1]

(c) In order to investigate electrical discharges (lightning) in a laboratory, an isolated metal sphere of radius 63 cm is charged to a potential of 1.2×10^6 V.

At this potential, there is an electrical discharge in which the sphere loses 75% of its energy.

Calculate

(i) the capacitance of the sphere, stating the unit in which it is measured,

capacitance = ... [3]

(ii) the potential of the sphere after the discharge has taken place.

potential = ... V [3]

3 A solid metal sphere, of radius *r*, is insulated from its surroundings. The sphere has charge +*Q*.
This charge is on the surface of the sphere but it may be considered to be a point charge at its centre, as illustrated in Fig. 5.1.

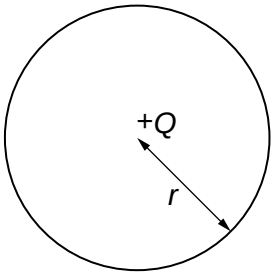

Fig. 5.1

(a) (i) Define *capacitance*.

.....

..... [1]

(ii) Show that the capacitance *C* of the sphere is given by the expression

$$C = 4\pi\varepsilon_0 r.$$

[1]

(b) The sphere has radius 36 cm.
Determine, for this sphere,

(i) the capacitance,

capacitance = ... F [1]

(ii) the charge required to raise the potential of the sphere from zero to 7.0×10^5 V.

charge = ... C [1]

(c) Suggest why your calculations in **(b)** for the metal sphere would not apply to a plastic sphere.

.....

.....

.....

..... [3]

(d) A spark suddenly connects the metal sphere in **(b)** to the Earth, causing the potential of the sphere to be reduced from 7.0×10^5V to 2.5×10^5V.

Calculate the energy dissipated in the spark.

energy = ... J [3]

4 A capacitor C is charged using a supply of e.m.f. 8.0V. It is then discharged through a resistor R.
The circuit is shown in Fig. 5.1.

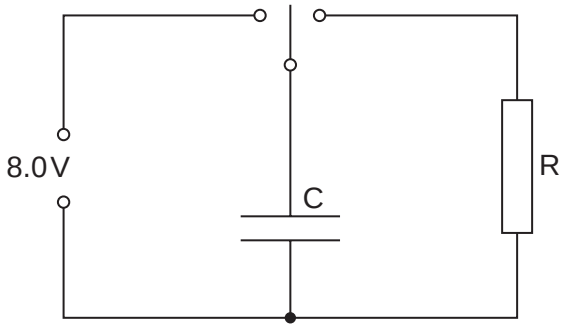

Fig. 5.1

The variation with time *t* of the potential difference *V* across the resistor R during the discharge of the capacitor is shown in Fig. 5.2.

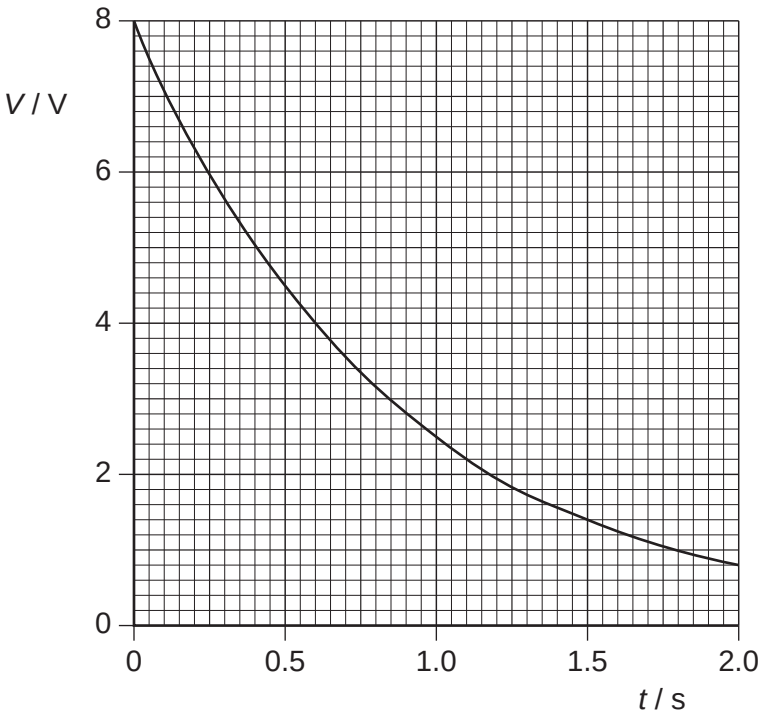

Fig. 5.2

(a) During the first 1.0 s of the discharge of the capacitor, 0.13 J of energy is transferred to the resistor R.
Show that the capacitance of the capacitor C is 4500 μF.

[3]

(b) Some capacitors, each of capacitance 4500 μF with a maximum working voltage of 6 V, are available.

Draw an arrangement of these capacitors that could provide a total capacitance of 4500 μF for use in the circuit of Fig. 5.1.

[2]

5 **(a)** State one function of capacitors in simple circuits.

.....

.....[1]

(b) A capacitor is charged to a potential difference of 15 V and then connected in series with a switch, a resistor of resistance 12 kΩ and a sensitive ammeter, as shown in Fig. 5.1.

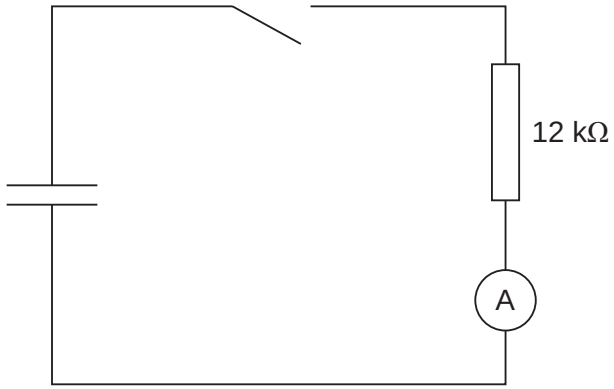

Fig. 5.1

The switch is closed and the variation with time t of the current I in the circuit is shown in Fig. 5.2.

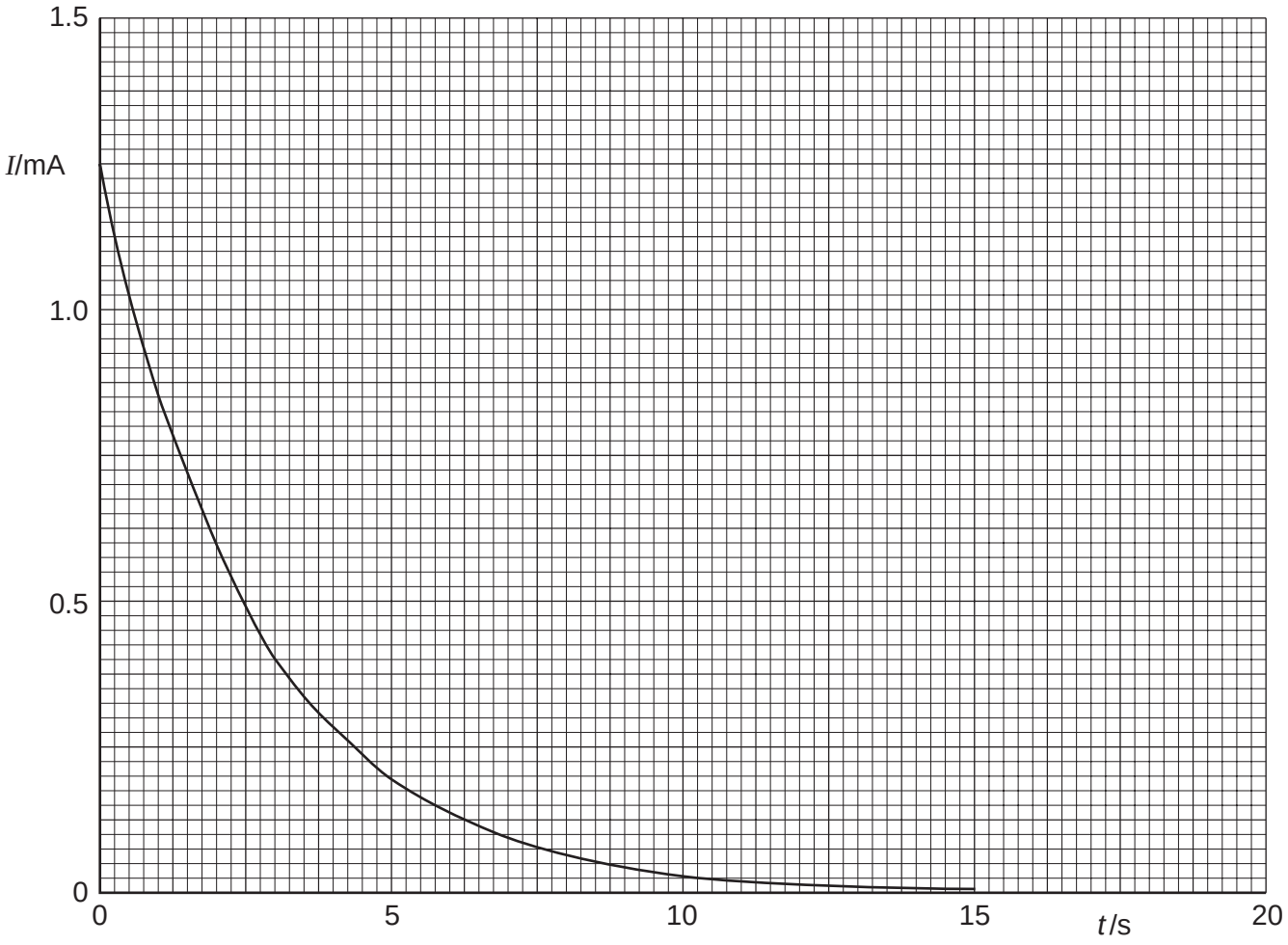

Fig. 5.2

(i) State the relation between the current in a circuit and the charge that passes a point in the circuit.

.....

.....[1]

(ii) The area below the graph line of Fig. 5.2 represents charge.
Use Fig. 5.2 to determine the initial charge stored in the capacitor.

charge = ... μC [4]

(iii) Initially, the potential difference across the capacitor was 15 V.
Calculate the capacitance of the capacitor.

capacitance = ... μF [2]

(c) The capacitor in **(b)** discharges one half of its initial energy. Calculate the new potential difference across the capacitor.

potential difference = ...V [3]

6 An alternating supply of frequency 50 Hz and having an output of 6.0 V r.m.s. is to be rectified so as to provide direct current for a resistor R. The circuit of Fig. 6.1 is used.

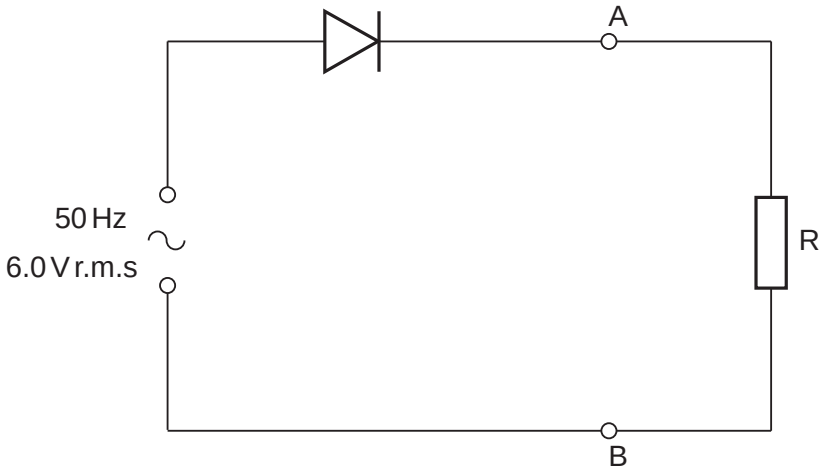

Fig. 6.1

The diode is ideal. The Y-plates of a cathode-ray oscilloscope (c.r.o.) are connected between points A and B.

(a) **(i)** Calculate the maximum potential difference across the diode during one cycle.

potential difference = …… V [2]

(ii) State the potential difference across R when the diode has maximum potential difference across it. Give a reason for your answer.

.....

..... [1]

(b) The Y-plate sensitivity of the c.r.o. is set at 2.0 V cm^{-1} and the time-base at 5.0 ms cm^{-1}.

On Fig. 6.2, draw the waveform that is seen on the screen of the c.r.o. [3]

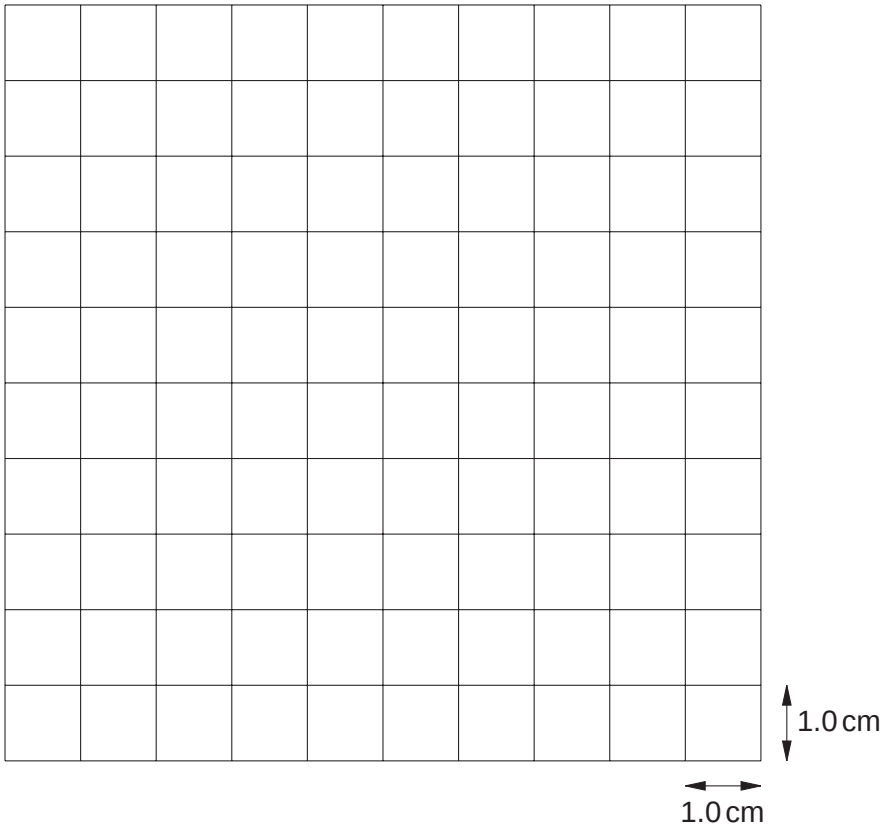

Fig. 6.2

(c) A capacitor of capacitance 180 µF is connected into the circuit to provide smoothing of the potential difference across the resistor R.

(i) On Fig. 6.1, show the position of the capacitor in the circuit. [1]

(ii) Calculate the energy stored in the fully-charged capacitor.

energy = ... J [3]

(iii) During discharge, the potential difference across the capacitor falls to $0.43\,V_0$, where V_0 is the maximum potential difference across the capacitor.

Calculate the fraction of the total energy that remains in the capacitor after the discharge.

fraction = …… [2]

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

.....

.....[1]

(b) **(i)** One use of a capacitor is for the storage of electrical energy.
Briefly explain how a capacitor stores energy.

.....

.....

.....[2]

(ii) Calculate the change in the energy stored in a capacitor of capacitance 1200 μF when the potential difference across the capacitor changes from 50 V to 15 V.

energy change = ... J [3]

8 Some capacitors are marked '48 μF, safe working voltage 25 V'.

Show how a number of these capacitors may be connected to provide a capacitor of capacitance

(a) 48 μF, safe working voltage 50 V,

[2]

(b) 72 μF, safe working voltage 25 V.

[2]

9 The rectified output of a sinusoidal signal generator is connected across a resistor **R** of resistance 1.5 k, as shown in Fig. 4.1.

Fig. 4.1

The variation with time *t* of the potential difference *V* across **R** is shown in Fig. 4.2.

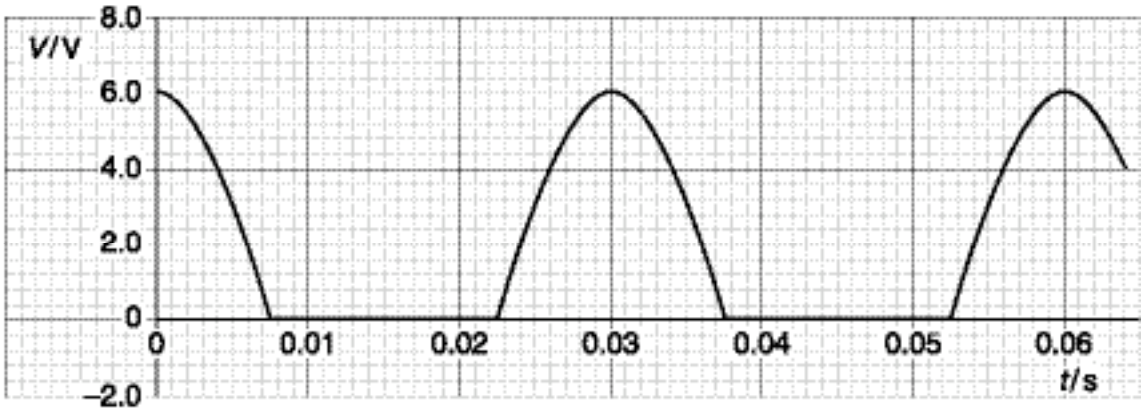

Fig. 4.2

(a) State how the rectification shown in Fig. 4.2 may be achieved.

.....

..... [2]

(b) A capacitor is now connected in parallel with the resistor **R**. The resulting variation with time *t* of the potential difference *V* across **R** is shown in Fig. 4.3.

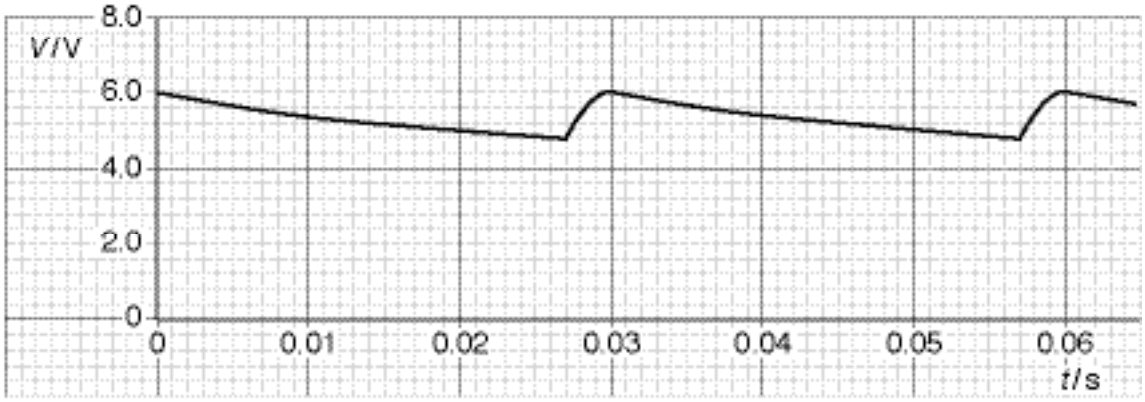

Fig. 4.3

(i) Using Fig. 4.3, determine

1. the mean potential difference across the resistor **R**,

potential difference = …….. V

2. the mean current in the resistor,

mean current = …….. A

3. the time in each cycle during which the capacitor discharges through the resistor.

time = …….. s

[4]

(ii) Using your answers in **(i)**, calculate

1. the charge passing through the resistor during one discharge of the capacitor,

charge = …….. C

2. the capacitance of the capacitor.

capacitance = …….. F
[4]

(c) A second capacitor is now connected in parallel with the resistor **R** and the first capacitor. On Fig. 4.3, draw a line to show the variation with time *t* of the potential difference *V* across the resistor. [1]