CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



EXAM QUESTION PACK

19 CAPACITANCE

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Chapter 9

Capacitance

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196. 9702_m21_qp_42 Q: 6

(a) State a similarity between the gravitational field lines around a point mass and the electric field lines around a point charge.

.....

..... [1]

(b) The variation with radius r of the electric field strength E due to an isolated charged sphere in a vacuum is shown in Fig. 6.1.

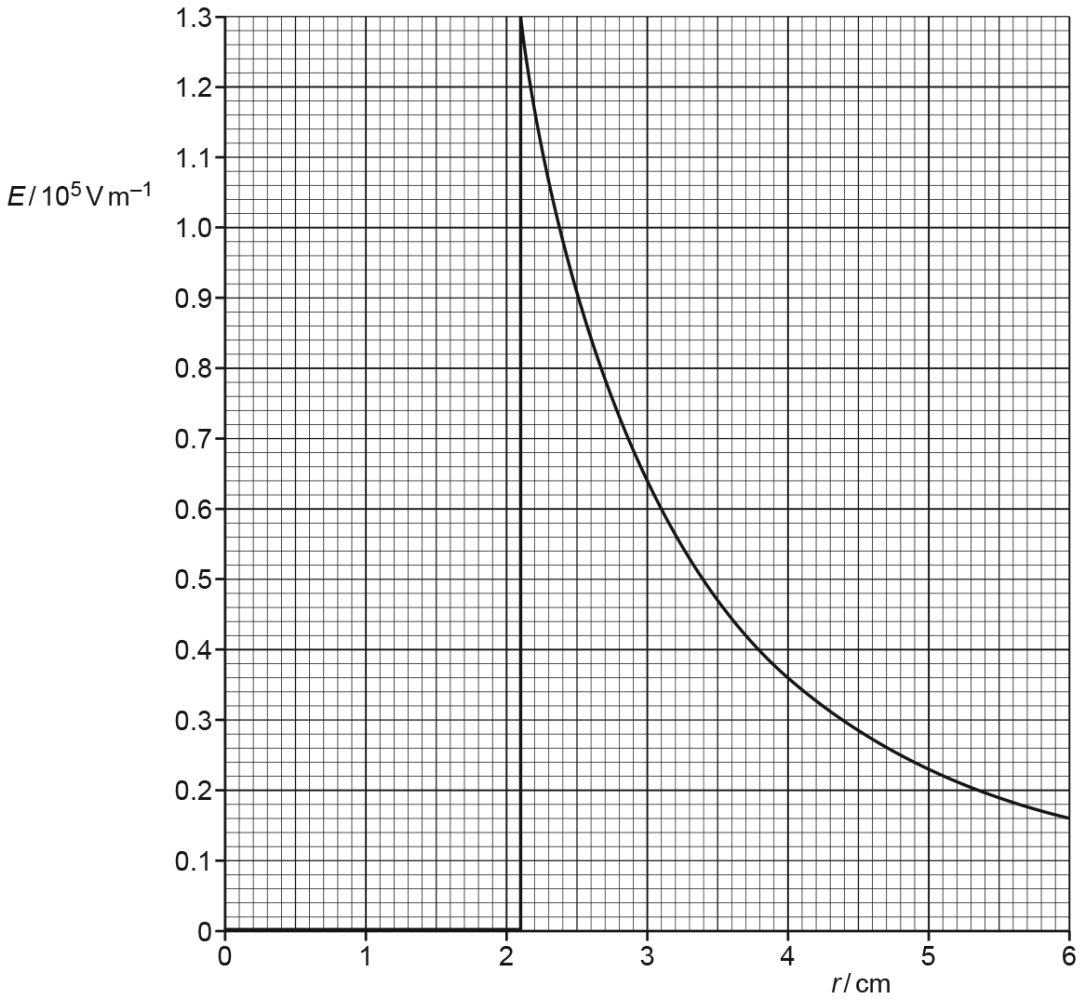


Fig. 6.1

Use data from Fig. 6.1 to:

(i) state the radius of the sphere

radius = ... cm [1]

(ii) calculate the charge on the sphere.

charge = ... C [2]

(c) Using the formula for the electric potential due to an isolated point charge, determine the capacitance of the sphere in **(b)**.

capacitance = ... F [3]

[Total: 7]

---

197. 9702_s21_qp_41 Q: 7

(a) State what is meant by the *capacitance* of a parallel plate capacitor.

.....

.....

..... [2]

(b) A capacitor of capacitance C is connected into the circuit shown in Fig. 7.1.

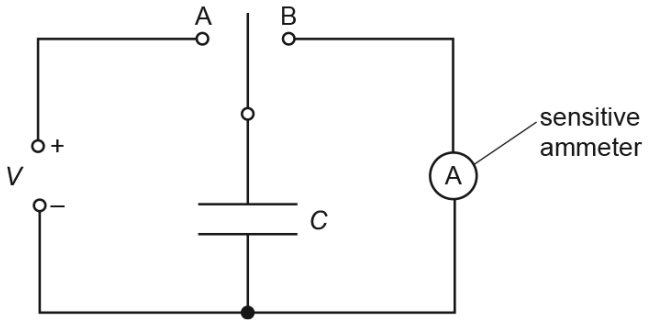


Fig. 7.1

When the two-way switch is in position A, the capacitor is charged so that the potential difference across it is V.
The switch moves to position B and the capacitor fully discharges through the sensitive ammeter.

The switch moves repeatedly between A and B so that the capacitor charges and then discharges with frequency f.

(i) Show that the average current I in the ammeter is given by the expression

$$I = fCV.$$

[2]

(ii) For a potential difference V of 150 V and a frequency f of 60 Hz, the average current in the ammeter is 4.8 μA.

Calculate the capacitance, in pF, of the capacitor.

capacitance = ... pF [2]

(c) A second capacitor, having the same capacitance as the capacitor in **(b)**, is connected into the circuit of Fig. 7.1. The two capacitors are connected in series.

State and explain the new reading on the ammeter.

new reading = ... μA

.....

.....

..... [3]

[Total: 9]

198. 9702_s21_qp_42 Q: 6

(a) Two flat metal plates are held a small distance apart by means of insulating pads, as shown in Fig. 6.1.

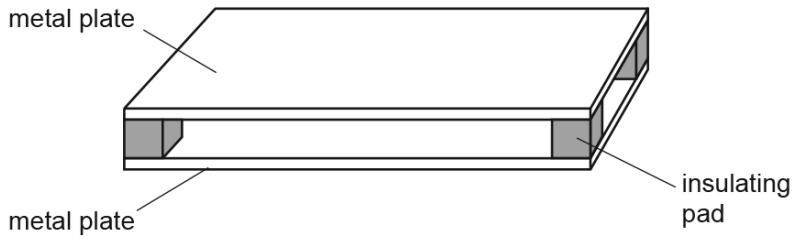


Fig. 6.1

Explain how the plates could act as a capacitor.

.....

.....

..... [2]

(b) The arrangement in Fig. 6.1 has capacitance *C*.
The arrangement is connected into the circuit of Fig. 6.2.

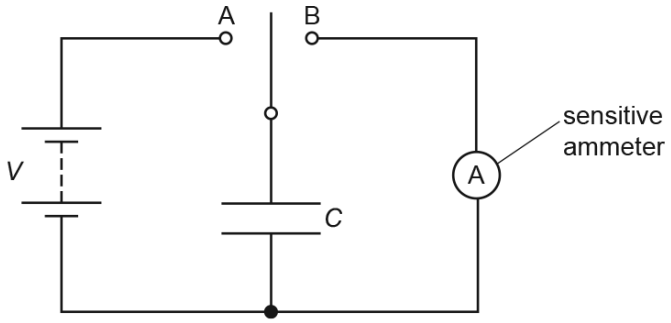


Fig. 6.2

When the two-way switch is moved to position A, the capacitor is charged so that the potential difference across it is *V*. When the switch moves to position B, the capacitor fully discharges through the sensitive ammeter.

The switch moves repeatedly between A and B so that the capacitor charges and then discharges with frequency *f*.

(i) Show that the average current I in the ammeter is given by

$$I = CVf.$$

[2]

(ii) For a potential difference V of 180 V and a frequency f of switching of 50 Hz, the average current I in the ammeter is 2.5 μA.

Calculate the capacitance, in pF, of the parallel plates.

capacitance = ... pF [2]

(c) A second capacitor is connected into the circuit of Fig. 6.2.
The two capacitors are connected in parallel.

State and explain the change, if any, in the average current in the ammeter.

.....

.....

..... [2]

[Total: 8]

199. 9702_s21_qp_43 Q: 7

(a) State what is meant by the *capacitance* of a parallel plate capacitor.

.....

.....

..... [2]

(b) A capacitor of capacitance C is connected into the circuit shown in Fig. 7.1.

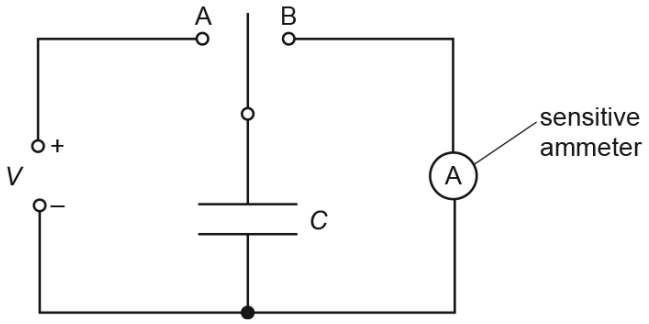


Fig. 7.1

When the two-way switch is in position A, the capacitor is charged so that the potential difference across it is V.
The switch moves to position B and the capacitor fully discharges through the sensitive ammeter.

The switch moves repeatedly between A and B so that the capacitor charges and then discharges with frequency f.

(i) Show that the average current I in the ammeter is given by the expression

$$I = fCV.$$

[2]

(ii) For a potential difference V of 150 V and a frequency f of 60 Hz, the average current in the ammeter is 4.8 μA.

Calculate the capacitance, in pF, of the capacitor.

capacitance = ... pF [2]

(c) A second capacitor, having the same capacitance as the capacitor in **(b)**, is connected into the circuit of Fig. 7.1. The two capacitors are connected in series.

State and explain the new reading on the ammeter.

new reading = ... μA

.....

.....

..... [3]

[Total: 9]

200. 9702_w21_qp_42 Q: 6

(a) Define *electric potential*.

.....

.....

..... [2]

(b) An isolated conducting sphere in a vacuum has radius r and is initially uncharged. It is then charged by friction so that it carries a final charge Q. This charge can be considered to be acting at the centre of the sphere.

By considering the electric potential at its surface, show that the capacitance C of the sphere is given by

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

where ε_0 is the permittivity of free space.

[2]

(c) The dome of an electrostatic generator is a spherical conductor of radius 13 cm. It is initially charged so that the electric potential at the surface is 4.5 kV.

A smaller isolated sphere of radius 5.2 cm, initially uncharged, is brought near to the dome. Sparking causes a current between the two spheres until they reach the same potential. Assume that any charge on a sphere may be considered to act as a point charge at its centre.

Calculate the charge that is transferred between the two spheres.

charge = ... C [3]

[Total: 7]

201. 9702_m20_qp_42 Q: 6

Two positively charged identical metal spheres A and B have their centres separated by a distance of 24 cm, as shown in Fig. 6.1.

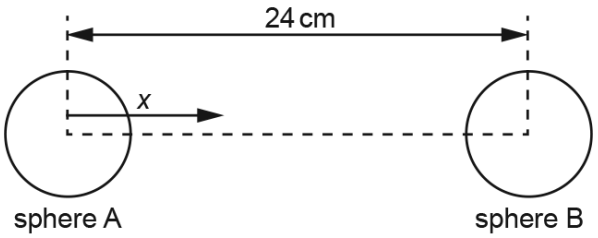


Fig. 6.1 (not to scale)

The variation with distance x from the centre of A of the electric field strength E due to the two spheres, along the line joining their centres, is represented in Fig. 6.2.

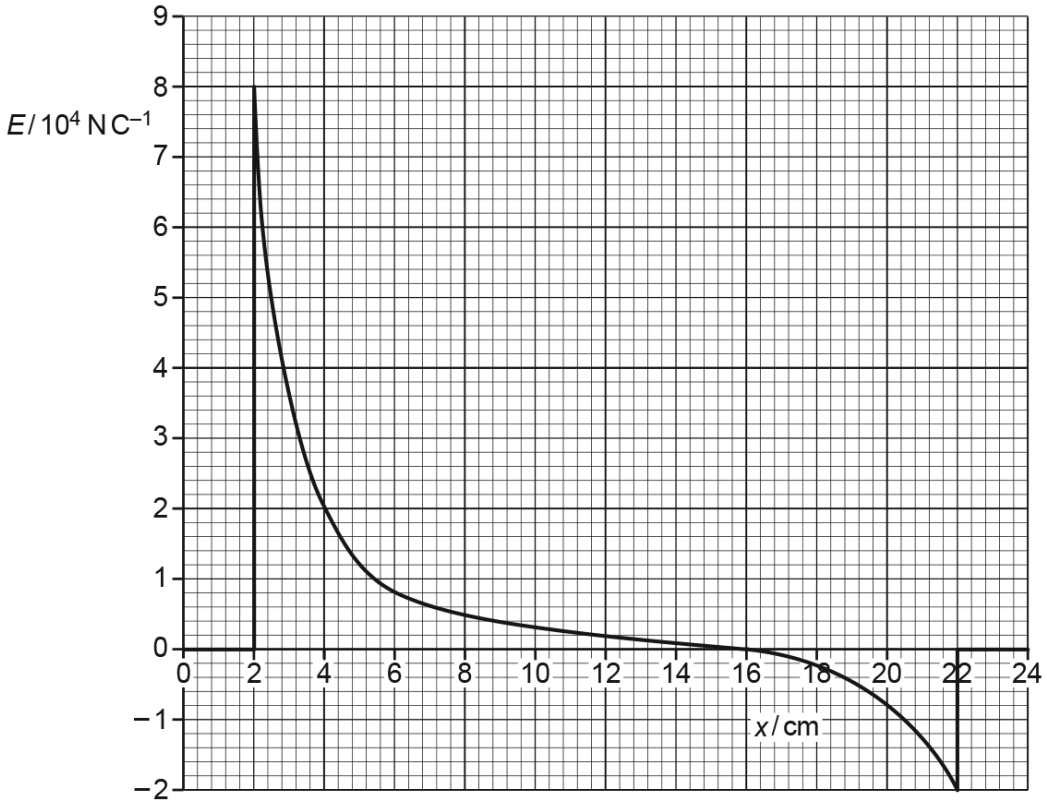


Fig. 6.2

(a) State the radius of the two spheres.

radius = ... cm [1]

(b) The charge on sphere A is 3.6×10^{-9} C. Determine the charge Q_B on sphere B.

Assume that spheres A and B can be treated as point charges at their centres.

Explain your working.

Q_B = ... C [3]

(c) **(i)** Sphere B is removed.

Use information from **(b)** to determine the electric potential on the surface of sphere A.

electric potential = ... V [2]

(ii) Calculate the capacitance of sphere A.

capacitance = ... F [2]

[Total: 8]

---

202. 9702_s19_qp_41 Q: 6

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

1. .....

.....

2. .....

.....

[2]

(b) Three uncharged capacitors of capacitances C_1, C_2 and C_3 are connected in series with a battery of electromotive force (e.m.f.) E and a switch, as shown in Fig. 6.1.

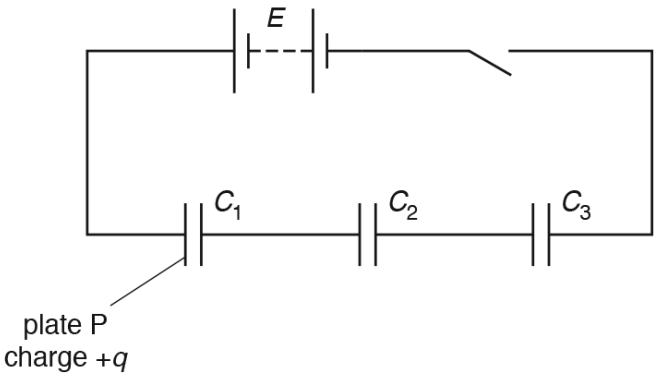


Fig. 6.1

When the switch is closed, there is a charge $+q$ on plate P of the capacitor of capacitance C_1.

Show that the combined capacitance C of the three capacitors is given by the expression

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

[3]

(c) A student has available four capacitors, each of capacitance 20 μF.

Draw circuit diagrams, one in each case, to show how the student may connect some or all of the capacitors to produce a combined capacitance of:

(i) 60 μF

[1]

(ii) 15 μF.

[1]

[Total: 7]

203. 9702_s19_qp_43 Q: 6

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

1. .....

.....

2. .....

.....

[2]

(b) Three uncharged capacitors of capacitances C_1, C_2 and C_3 are connected in series with a battery of electromotive force (e.m.f.) E and a switch, as shown in Fig. 6.1.

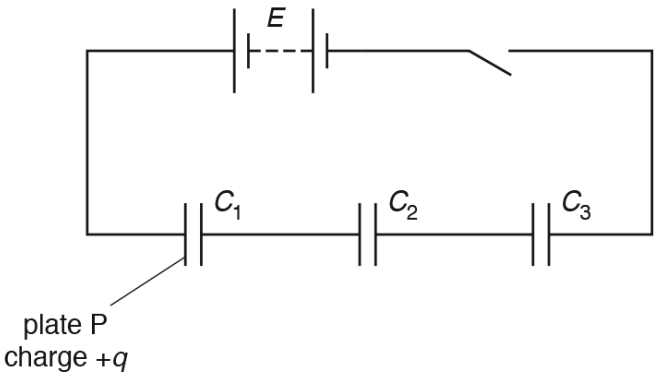


Fig. 6.1

When the switch is closed, there is a charge $+q$ on plate P of the capacitor of capacitance C_1.

Show that the combined capacitance C of the three capacitors is given by the expression

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

[3]

(c) A student has available four capacitors, each of capacitance 20 μF.

Draw circuit diagrams, one in each case, to show how the student may connect some or all of the capacitors to produce a combined capacitance of:

(i) 60 μF

[1]

(ii) 15 μF.

[1]

[Total: 7]

204. 9702_s18_qp_41 Q: 7

(a) Explain what is meant by the *capacitance* of a parallel plate capacitor.

.....

.....

.....

.....[3]

(b) A parallel plate capacitor C is connected into the circuit shown in Fig. 7.1.

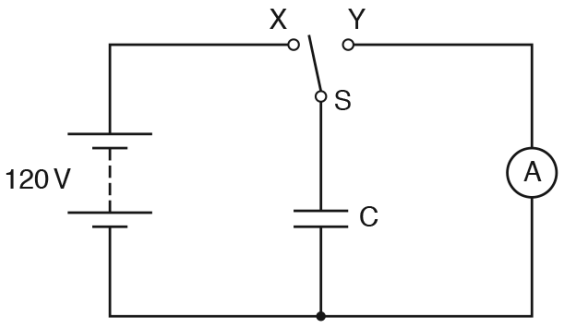


Fig. 7.1

When switch S is at position X, the battery of electromotive force 120 V and negligible internal resistance is connected to capacitor C.
When switch S is at position Y, the capacitor C is discharged through the sensitive ammeter.

The switch vibrates so that it is first in position X, then moves to position Y and then back to position X fifty times each second.

The current recorded on the ammeter is 4.5 μA.

Determine

(i) the charge, in coulomb, passing through the ammeter in 1.0 s,

charge = ... C [1]

(ii) the charge on one plate of the capacitor, each time that it is charged,

charge = ... C [1]

(iii) the capacitance of capacitor C.

capacitance = ... F [2]

(c) A second capacitor, having a capacitance equal to that of capacitor C, is now placed in series with C.

Suggest and explain the effect on the current recorded on the ammeter.

.....

.....

.....[2]

[Total: 9]

---

205. 9702_s18_qp_43 Q: 7

(a) Explain what is meant by the *capacitance* of a parallel plate capacitor.

.....

.....

.....

.....[3]

(b) A parallel plate capacitor C is connected into the circuit shown in Fig. 7.1.

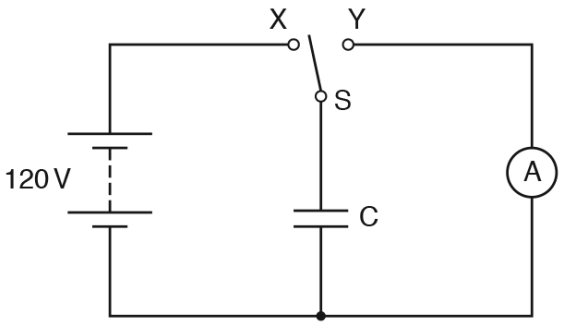


Fig. 7.1

When switch S is at position X, the battery of electromotive force 120 V and negligible internal resistance is connected to capacitor C.
When switch S is at position Y, the capacitor C is discharged through the sensitive ammeter.

The switch vibrates so that it is first in position X, then moves to position Y and then back to position X fifty times each second.

The current recorded on the ammeter is 4.5 μA.

Determine

(i) the charge, in coulomb, passing through the ammeter in 1.0 s,

charge = ... C [1]

(ii) the charge on one plate of the capacitor, each time that it is charged,

charge = ... C [1]

(iii) the capacitance of capacitor C.

capacitance = ... F [2]

(c) A second capacitor, having a capacitance equal to that of capacitor C, is now placed in series with C.

Suggest and explain the effect on the current recorded on the ammeter.

.....

.....

.....[2]

[Total: 9]

---

206. 9702_w17_qp_41 Q: 6

Two capacitors P and Q, each of capacitance *C*, are connected in series with a battery of e.m.f. 9.0 V, as shown in Fig. 6.1.

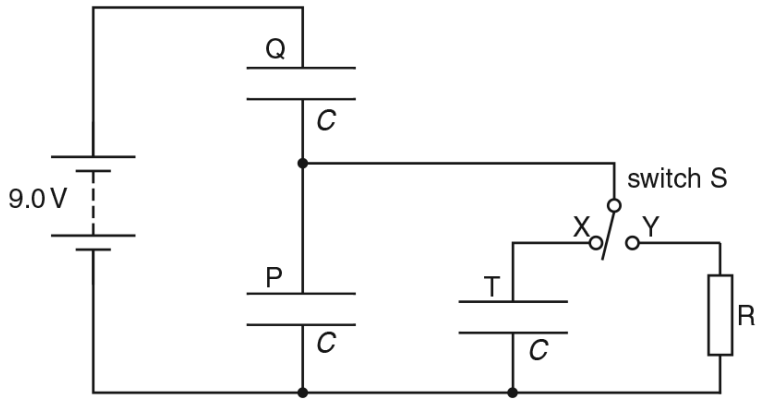


Fig. 6.1

A switch S is used to connect either a third capacitor T, also of capacitance *C*, or a resistor R, in parallel with capacitor P.

(a) Switch S is in position X.

Calculate

(i) the combined capacitance, in terms of *C*, of the three capacitors,

capacitance = ... [2]

(ii) the potential difference across capacitor Q. Explain your working.

potential difference = ... V [2]

(b) Switch S is now moved to position Y.
State what happens to the potential difference across capacitor P and across capacitor Q.

capacitor P: .....

.....

.....

capacitor Q: .....

.....

.....
[4]

[Total: 8]

---

207. 9702_w17_qp_43 Q: 6

Two capacitors P and Q, each of capacitance *C*, are connected in series with a battery of e.m.f. 9.0 V, as shown in Fig. 6.1.

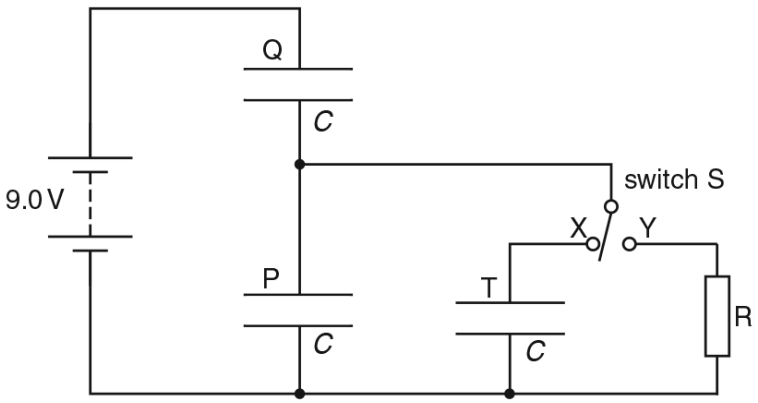


Fig. 6.1

A switch S is used to connect either a third capacitor T, also of capacitance *C*, or a resistor R, in parallel with capacitor P.

(a) Switch S is in position X.

Calculate

(i) the combined capacitance, in terms of *C*, of the three capacitors,

capacitance = ... [2]

(ii) the potential difference across capacitor Q. Explain your working.

potential difference = ... V [2]

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(b) Switch S is now moved to position Y.
State what happens to the potential difference across capacitor P and across capacitor Q.

capacitor P: .....

.....

.....

capacitor Q: .....

.....

.....

[4]

[Total: 8]

---

208. 9702_w16_qp_42 Q: 7

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

.....

.....[1]

(ii) Use the expression for the electric potential due to a point charge to show that an isolated metal sphere of diameter 25 cm has a capacitance of 1.4×10^{-11} F.

[2]

(b) Three capacitors of capacitances 2.0 μF, 3.0 μF and 4.0 μF are connected as shown in Fig. 7.1 to a battery of e.m.f. 9.0 V.

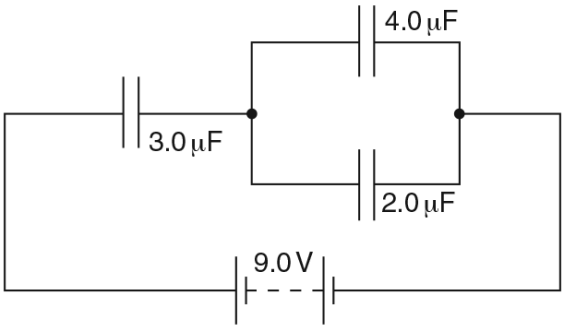


Fig. 7.1

Determine

(i) the combined capacitance of the three capacitors,

capacitance = ... μF [1]

(ii) the potential difference across the capacitor of capacitance 3.0 μF,

potential difference = ... V [2]

(iii) the positive charge stored on the capacitor of capacitance 2.0 μF.

charge = ... μC [2]

[Total: 8]

---

209. 9702_w21_qp_41 Q: 6

(a) A capacitor consists of two parallel metal plates, separated by air, at a variable distance *x* apart, as shown in Fig. 6.1. The capacitance *C* is inversely proportional to *x*.

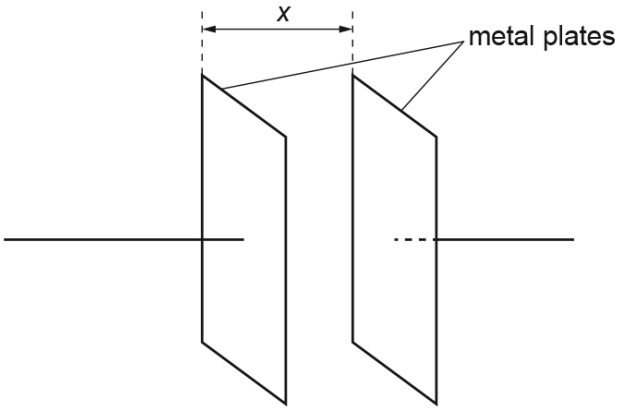


Fig. 6.1

The capacitor is charged by a supply so that there is a potential difference (p.d.) *V* between the plates.

State expressions, in terms of *C* and *V*, for the charge *Q* on one of the plates and for the energy *E* stored in the capacitor.

Q = ... *E* = ... [1]

(b) The charged capacitor in **(a)** is now disconnected from the supply. The plates of the capacitor are initially separated by distance *L*. They are then moved closer together by a distance *D*, as shown in Fig. 6.2.

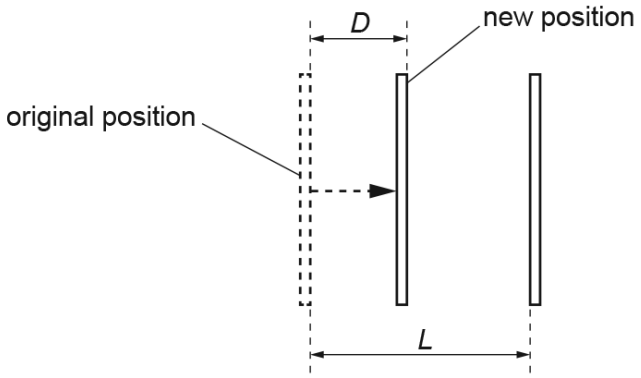


Fig. 6.2

State expressions, in terms of *C*, *V*, *L* and *D*, for:

(i) the new capacitance C_N

C_N = ... [1]

(ii) the new charge Q_N on one of the plates

Q_N = ... [1]

(iii) the new p.d. V_N between the plates.

V_N = ... [1]

(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]

[Total: 5]

---

210. 9702_w21_qp_43 Q: 6

(a) A capacitor consists of two parallel metal plates, separated by air, at a variable distance x apart, as shown in Fig. 6.1. The capacitance C is inversely proportional to x.

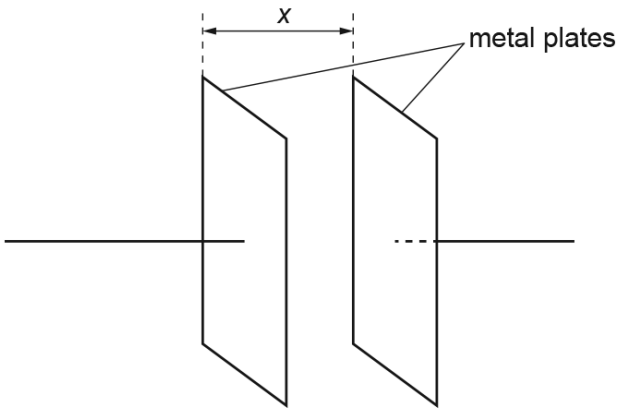


Fig. 6.1

The capacitor is charged by a supply so that there is a potential difference (p.d.) V between the plates.

State expressions, in terms of C and V, for the charge Q on one of the plates and for the energy E stored in the capacitor.

Q = ... E = ... [1]

(b) The charged capacitor in **(a)** is now disconnected from the supply. The plates of the capacitor are initially separated by distance L. They are then moved closer together by a distance D, as shown in Fig. 6.2.

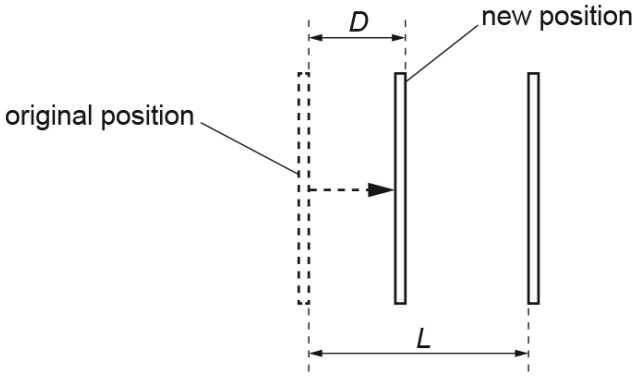


Fig. 6.2

State expressions, in terms of C, V, L and D, for:

(i) the new capacitance C_N

C_N = ... [1]

(ii) the new charge Q_N on one of the plates

Q_N = ... [1]

(iii) the new p.d. V_N between the plates.

V_N = ... [1]

(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]

[Total: 5]

---

211. 9702_m19_qp_42 Q: 6

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

.....

.....

..... [2]

(b) A student has three capacitors. Two of the capacitors have a capacitance of 4.0 μF and one has a capacitance of 8.0 μF.

Draw labelled circuit diagrams, one in each case, to show how the three capacitors may be connected to give a total capacitance of:

(i) 1.6 μF

[1]

(ii) 10 μF.

[1]

(c) A capacitor C of capacitance 47 μF is connected across the output terminals of a bridge rectifier, as shown in Fig. 6.1.

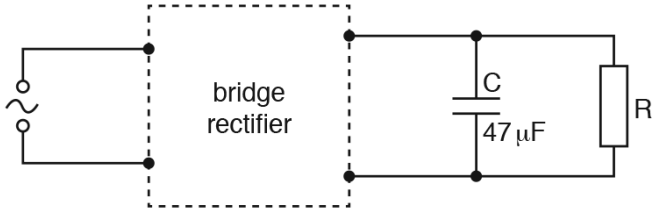


Fig. 6.1

The variation with time *t* of the potential difference *V* across the resistor R is shown in Fig. 6.2.

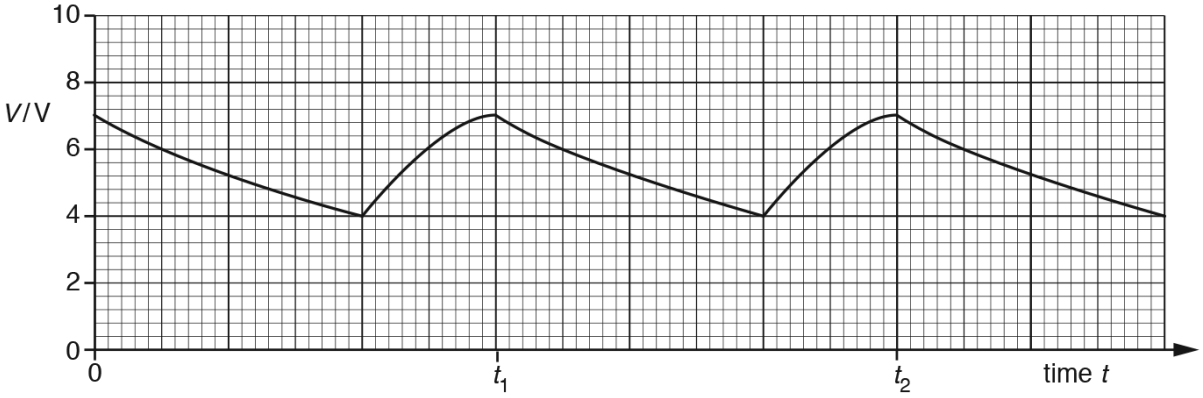


Fig. 6.2

Use data from Fig. 6.2 to determine the energy transfer from the capacitor C to the resistor R between time t_1 and time t_2.

energy = ...J [3]

[Total: 7]

212. 9702_s18_qp_42 Q: 6

(a) Explain what is meant by the *capacitance* of a parallel plate capacitor.

.....

.....

.....

.....[3]

(b) Three parallel plate capacitors each have a capacitance of 6.0 μF.

Draw circuit diagrams, one in each case, to show how the capacitors may be connected together to give a combined capacitance of

(i) 9.0 μF,

[1]

(ii) 4.0 μF.

[1]

(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.

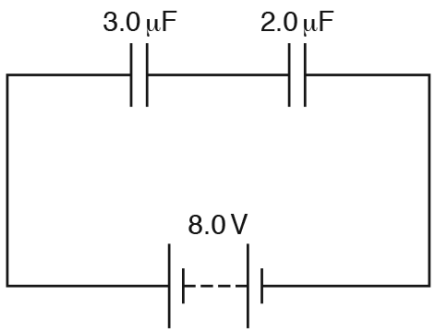


Fig. 6.1

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(i) Calculate the combined capacitance of the capacitors.

capacitance = ... μF [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]

[Total: 10]

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213. 9702_s17_qp_42 Q: 7

A capacitor consists of two parallel metal plates, separated by an insulator, as shown in Fig. 7.1.

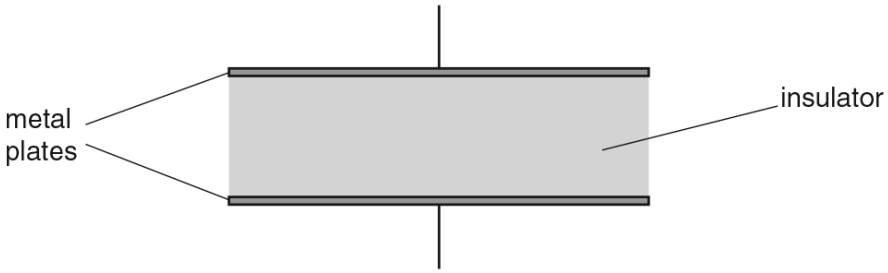


Fig. 7.1

(a) Suggest why, when the capacitor is connected across the terminals of a battery, the capacitor stores energy, not charge.

.....

.....

.....[2]

(b) Define the *capacitance* of the capacitor.

.....

.....

.....[2]

(c) The capacitor is charged so that the potential difference between its plates is V_0.
The capacitor is then connected across a resistor for a short time. It is then disconnected.
The energy stored in the capacitor is reduced to $\frac{1}{16}$ of its initial value.

Determine, in terms of V_0, the potential difference across the capacitor.

potential difference = ...[2]

[Total: 6]

214. 9702_m16_qp_42 Q: 7

(a) Define *capacitance*.

.....

.....[1]

(b) Three capacitors of capacitances C_1, C_2 and C_3 are initially uncharged. They are then connected in series to a battery, as shown in Fig. 7.1.

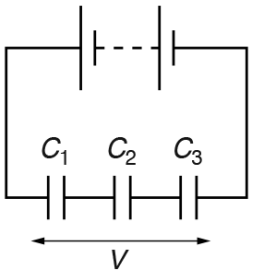


Fig. 7.1

The battery applies a potential difference V across the three capacitors.

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

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

[2]

(c) A battery of e.m.f. 12V and negligible internal resistance is connected to a network of two capacitors and a resistor, as shown in Fig. 7.2.

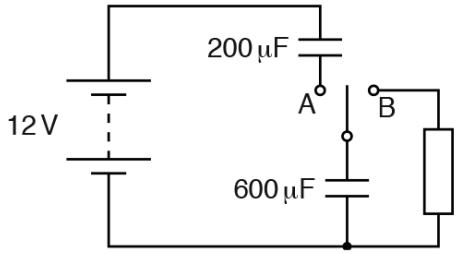


Fig. 7.2

The capacitors have capacitances of 200 μF and 600 μF. The switch has two positions, A and B.

(i) The switch is moved to position A.

Calculate

1. the combined capacitance of the two capacitors,

combined capacitance = ... μF [1]

2. the charge on the 600 μF capacitor,

charge = ... C [1]

3. the potential difference across the 600 μF capacitor.

potential difference = ... V [1]

(ii) The switch is now moved from position A to position B.

Calculate the potential difference across the 600 μF capacitor when it has discharged 50% of its initial energy.

potential difference = ... V [3]

[Total: 9]

Q1.

8 **(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]

Q2.

5 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.

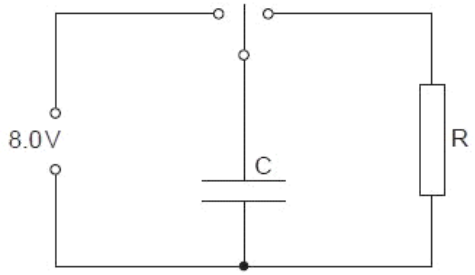


Fig. 5.1

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.

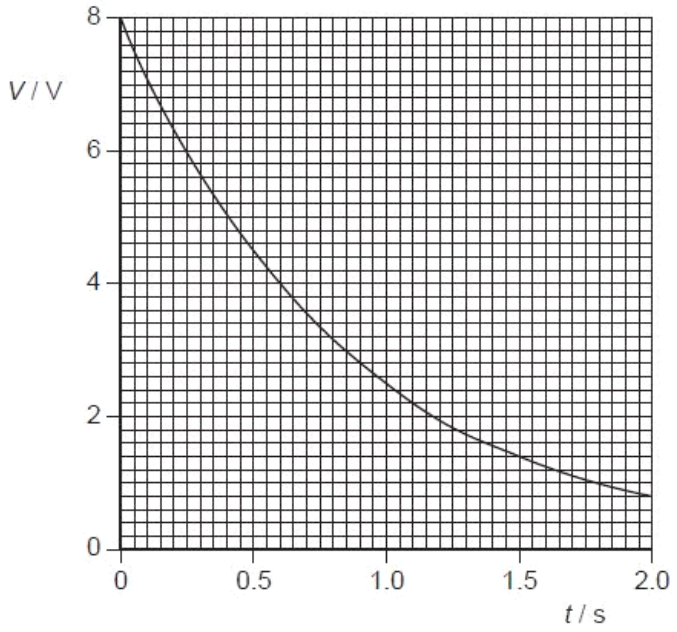


Fig. 5.2

(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 6V, 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]

Q3.

5 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.

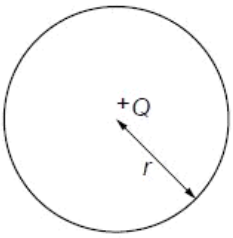


Fig. 5.1

(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]

Q4.

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

1. .....

2. .....

[2]

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

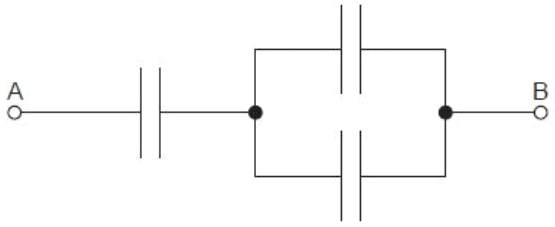


Fig. 5.1

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]

Q5.

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

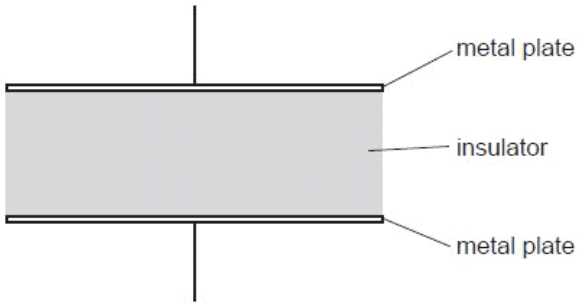


Fig. 3.1

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.

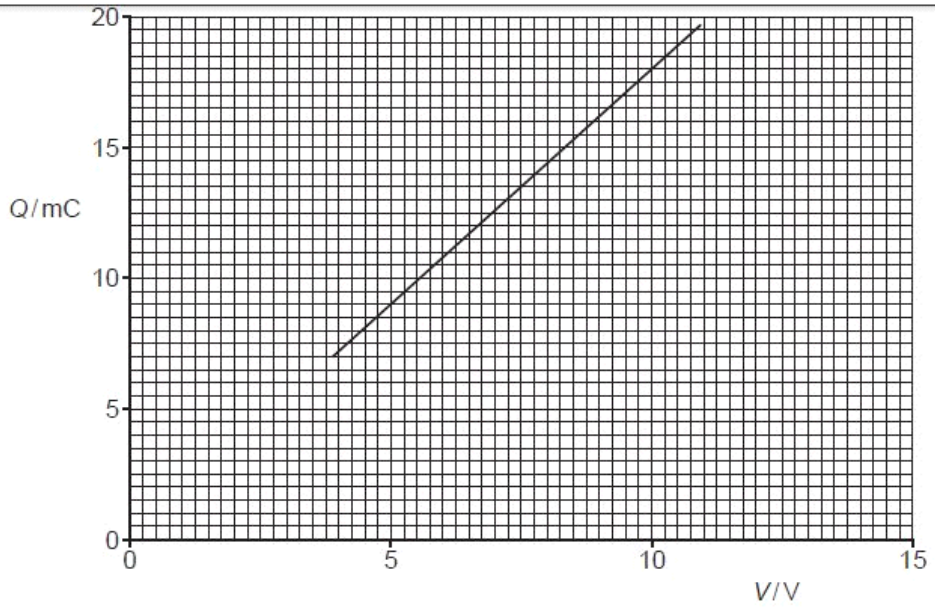


Fig. 3.2

(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 10.0V to 7.5V.

energy = ... mJ [2]

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

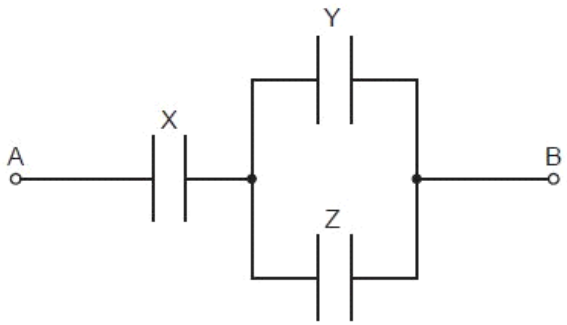


Fig. 3.3

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]

Q6.

5 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]

Q7.

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

.....

.....[1]

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

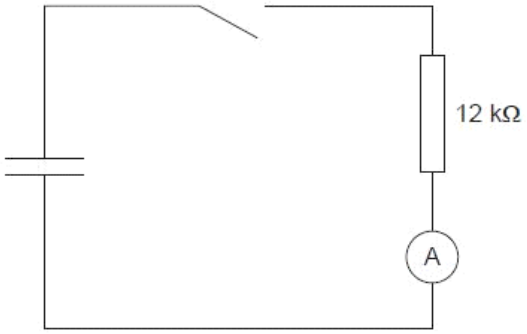


Fig. 5.1

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

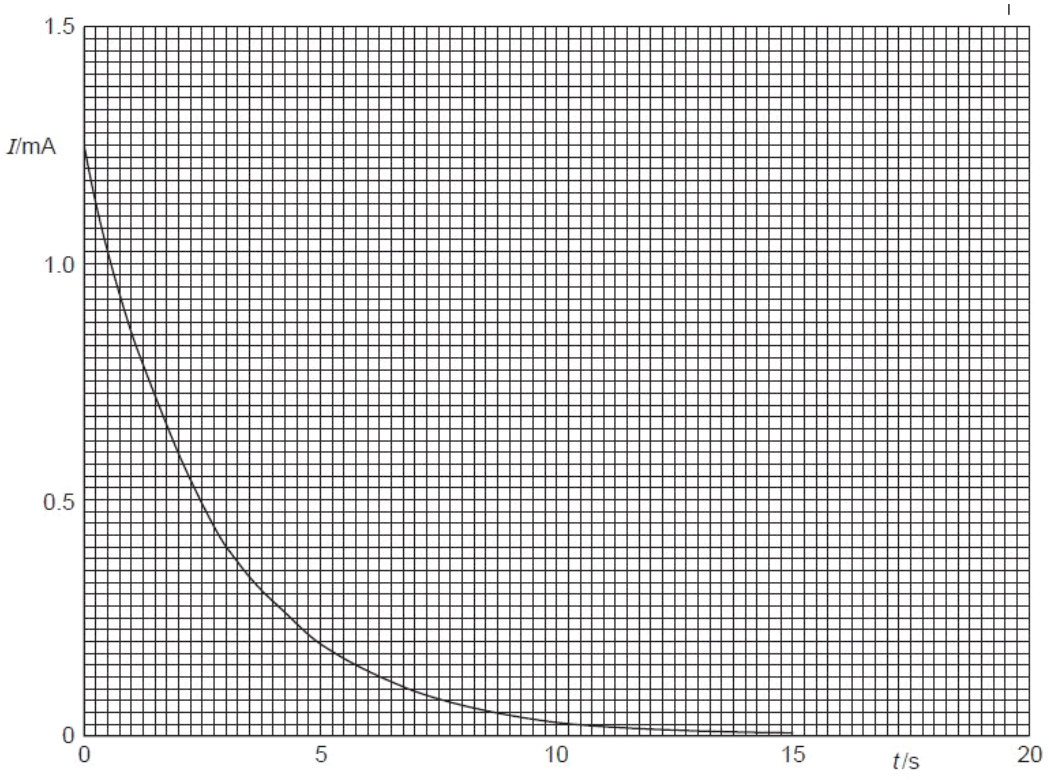


Fig. 5.2

(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 15V.
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]

Q8.

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

For Examiner's Use

.....

..... [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.

For Examiner's Use

potential = ... V [3]

Q9.

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

For Examiner's Use

.....

.....[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.

For Examin Use

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]

Q10.

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

For Examiner's Use

.....

.....

..... [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.

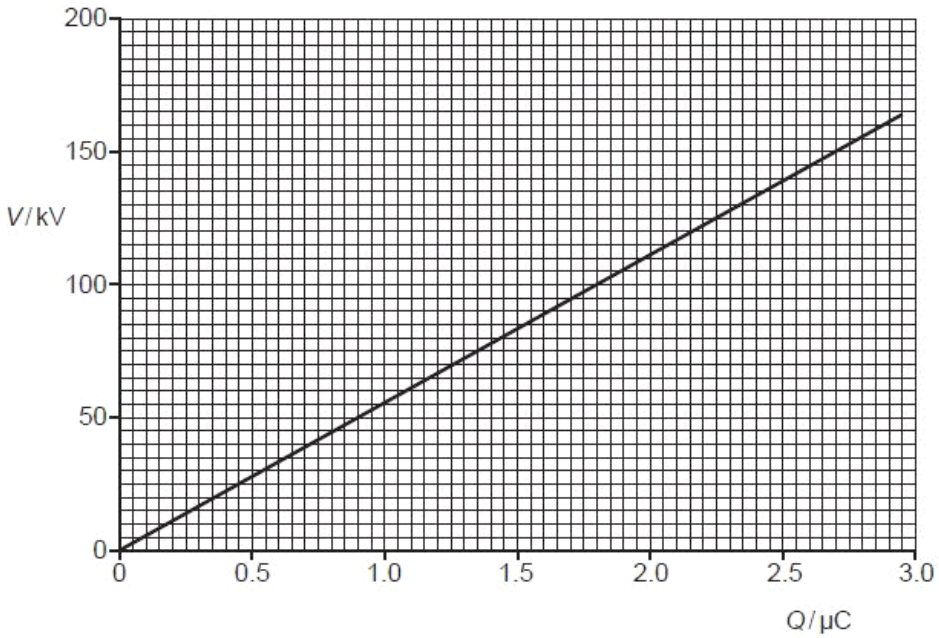


Fig. 4.1

An isolated metal sphere has capacitance.

For Examiner's Use

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]

Q11.

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

For Examiner's Use

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.

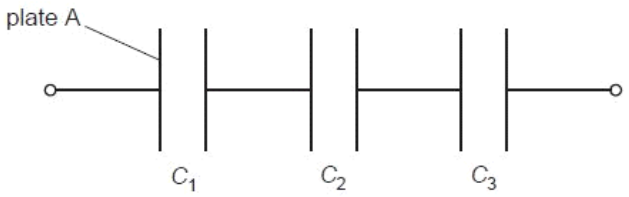


Fig. 4.1

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.

For Examiner's Use

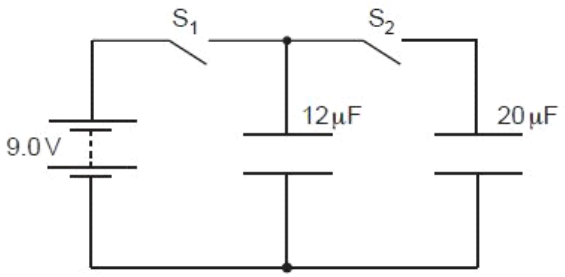


Fig. 4.2

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]

Q12.

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

For Examine Use

.....

.....[1]

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

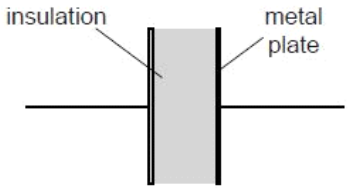


Fig. 5.1

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

.....

.....

.....

.....

.....[4]

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

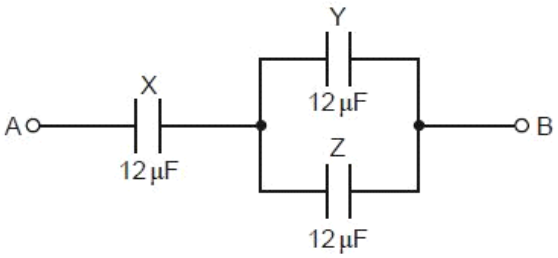


Fig. 5.2

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.

For Examiner's Use

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]

Q13.

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

For Examiner's Use

1. .....

.....

2. .....

.....

[2]

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

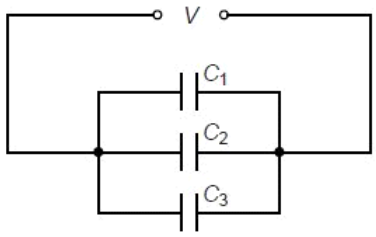


Fig. 4.1

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

For Examiner's Use

(i) 8 μF,

[1]

(ii) 18 μF.

[1]

Q14.

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

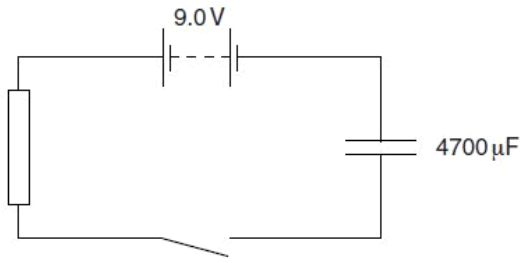


Fig. 6.1

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]

Q15.

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

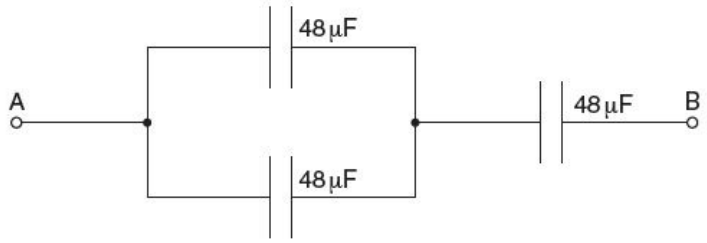


Fig. 6.1

(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]

1. Nov/2020/Paper_41/No.6

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

.....

.....

..... [2]

(ii) State **three** functions of capacitors in electrical circuits.

1. .....

2. .....

3. .....

[3]

(b) A student has available four capacitors, each of capacitance 24 μF.

The capacitors are connected as shown in Fig. 6.1.

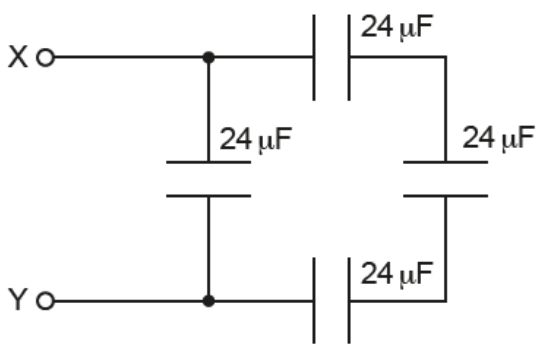


Fig. 6.1

Calculate the combined capacitance between the terminals X and Y.

capacitance = ... μF [2]

[Total: 7]

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2. Nov/2020/Paper_42/No.6

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

.....

.....

..... [2]

(ii) State **three** functions of capacitors in electrical circuits.

1. .....

2. .....

3. .....

[3]

(b) A student has available **three** capacitors, each of capacitance 12 μF.

Draw diagrams, one in each case, to show how the student connects the capacitors to give a combined capacitance between the terminals of:

(i) 18 μF



[1]

(ii) 8 μF.



[1]

[Total: 7]

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Capacitance – 2021 A2

1. Nov/2021/Paper_41/No.6

(a) A capacitor consists of two parallel metal plates, separated by air, at a variable distance x apart, as shown in Fig. 6.1. The capacitance C is inversely proportional to x.

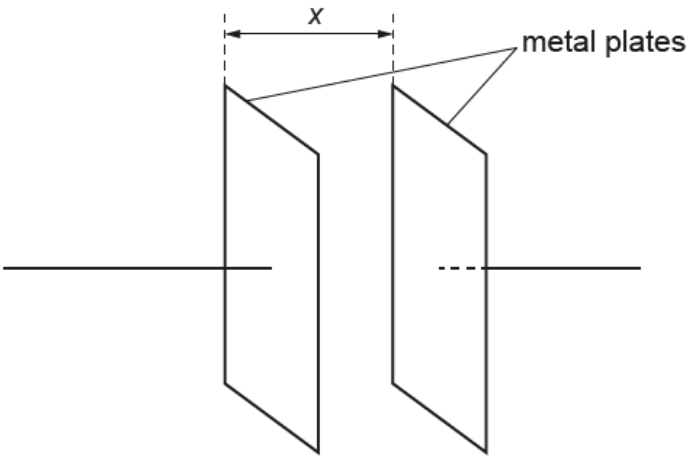


Fig. 6.1

The capacitor is charged by a supply so that there is a potential difference (p.d.) V between the plates.

State expressions, in terms of C and V, for the charge Q on one of the plates and for the energy E stored in the capacitor.

Q = ... E = ... [1]

(b) The charged capacitor in **(a)** is now disconnected from the supply. The plates of the capacitor are initially separated by distance L. They are then moved closer together by a distance D, as shown in Fig. 6.2.

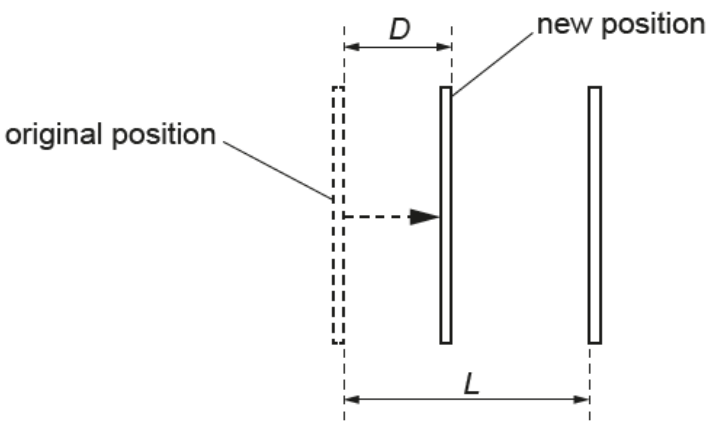


Fig. 6.2

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State expressions, in terms of C, V, L and D, for:

(i) the new capacitance C_N

C_N = ... [1]

(ii) the new charge Q_N on one of the plates

Q_N = ... [1]

(iii) the new p.d. V_N between the plates.

V_N = ... [1]

(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]

[Total: 5]

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2. June/2021/Paper_41/No.7

(a) State what is meant by the *capacitance* of a parallel plate capacitor.

.....

.....

..... [2]

(b) A capacitor of capacitance C is connected into the circuit shown in Fig. 7.1.

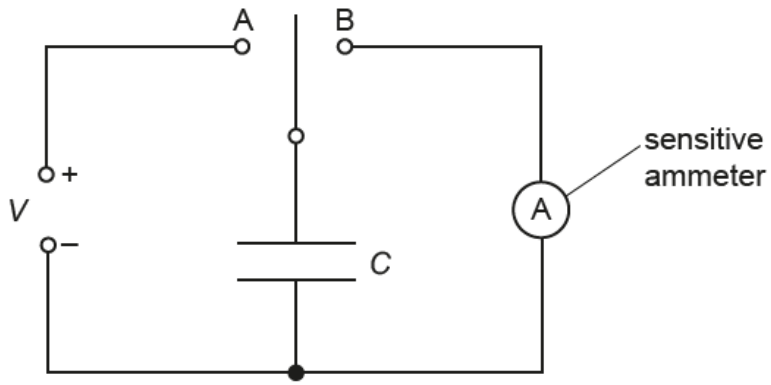


Fig. 7.1

When the two-way switch is in position A, the capacitor is charged so that the potential difference across it is V.
The switch moves to position B and the capacitor fully discharges through the sensitive ammeter.

The switch moves repeatedly between A and B so that the capacitor charges and then discharges with frequency f.

(i) Show that the average current I in the ammeter is given by the expression

$$I = fCV.$$

[2]

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(ii) For a potential difference V of 150 V and a frequency f of 60 Hz, the average current in the ammeter is 4.8 μA.

Calculate the capacitance, in pF, of the capacitor.

capacitance = ... pF [2]

(c) A second capacitor, having the same capacitance as the capacitor in **(b)**, is connected into the circuit of Fig. 7.1. The two capacitors are connected in series.

State and explain the new reading on the ammeter.

new reading = ... μA

.....

.....

..... [3]

[Total: 9]

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3. June/2021/Paper_42/No.6

(a) Two flat metal plates are held a small distance apart by means of insulating pads, as shown in Fig. 6.1.

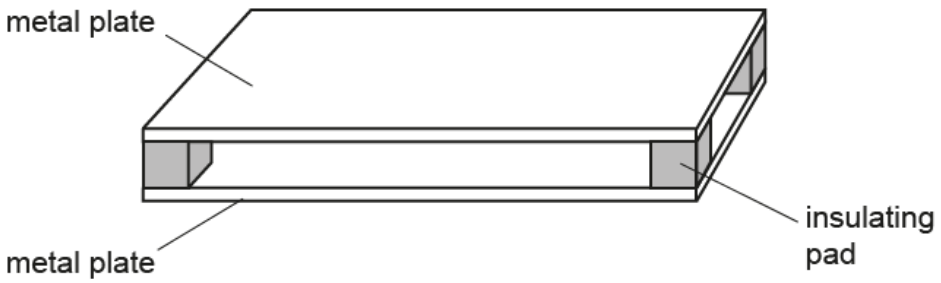


Fig. 6.1

Explain how the plates could act as a capacitor.

.....

.....

..... [2]

(b) The arrangement in Fig. 6.1 has capacitance *C*.
The arrangement is connected into the circuit of Fig. 6.2.

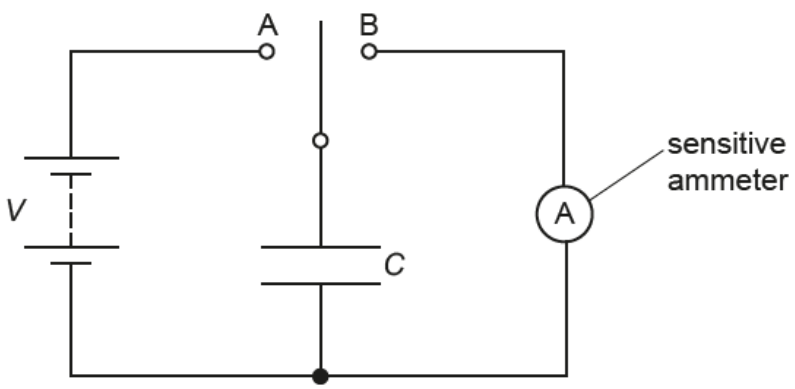


Fig. 6.2

When the two-way switch is moved to position A, the capacitor is charged so that the potential difference across it is *V*. When the switch moves to position B, the capacitor fully discharges through the sensitive ammeter.

The switch moves repeatedly between A and B so that the capacitor charges and then discharges with frequency *f*.

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(i) Show that the average current I in the ammeter is given by

$$I = CVf.$$

[2]

(ii) For a potential difference V of 180 V and a frequency f of switching of 50 Hz, the average current I in the ammeter is 2.5 μA.

Calculate the capacitance, in pF, of the parallel plates.

capacitance = ... pF [2]

(c) A second capacitor is connected into the circuit of Fig. 6.2.
The two capacitors are connected in parallel.

State and explain the change, if any, in the average current in the ammeter.

.....

.....

..... [2]

[Total: 8]

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1. Nov/2023/Paper_9702/42/No.6

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.

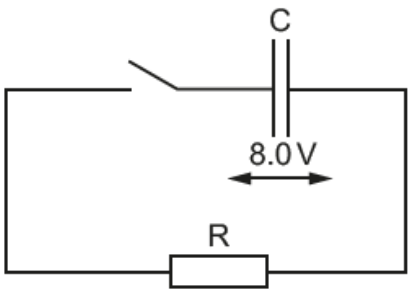


Fig. 6.1

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.

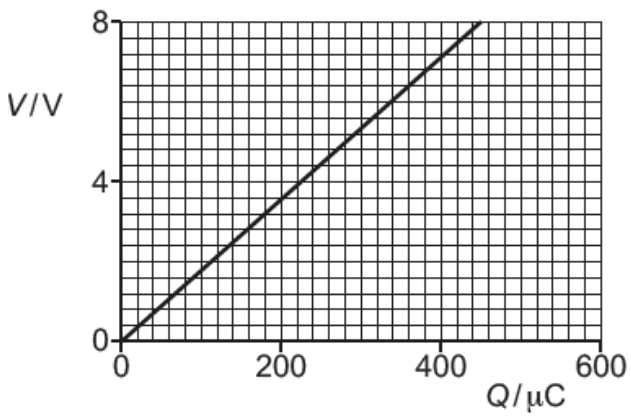


Fig. 6.2

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

[2]

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(ii) Determine the capacitance of capacitor C. Give a unit with your answer.

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

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

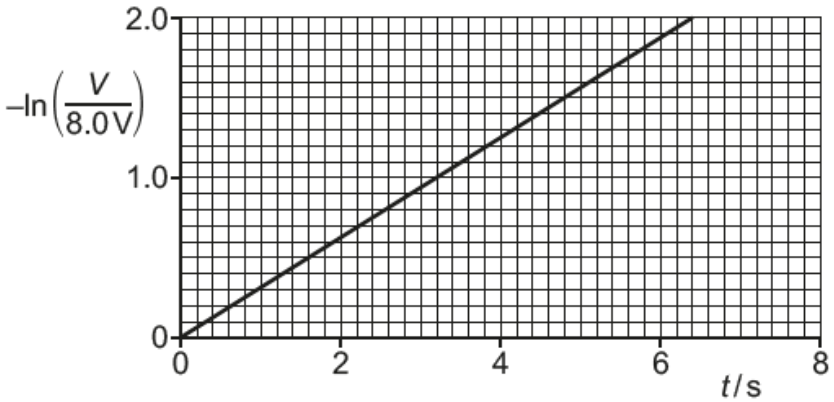


Fig. 6.3

(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]

[Total: 9]

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2. June/2023/Paper_9702/41/No.5(b)

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

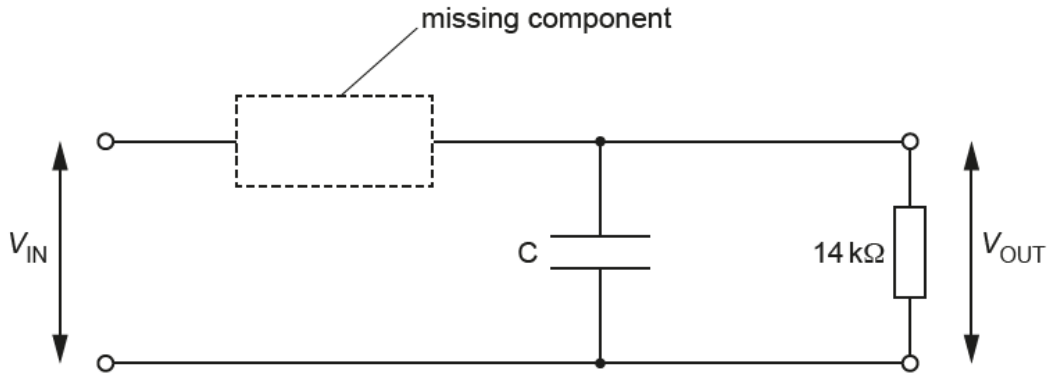


Fig. 5.1

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}.

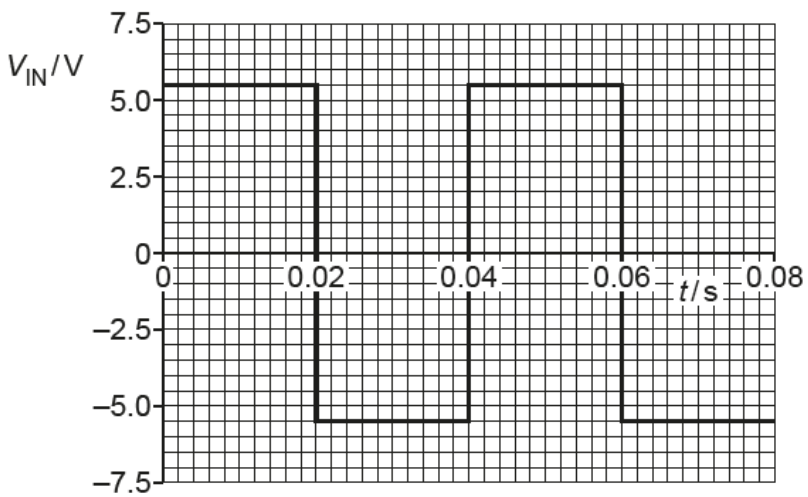


Fig. 5.2

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

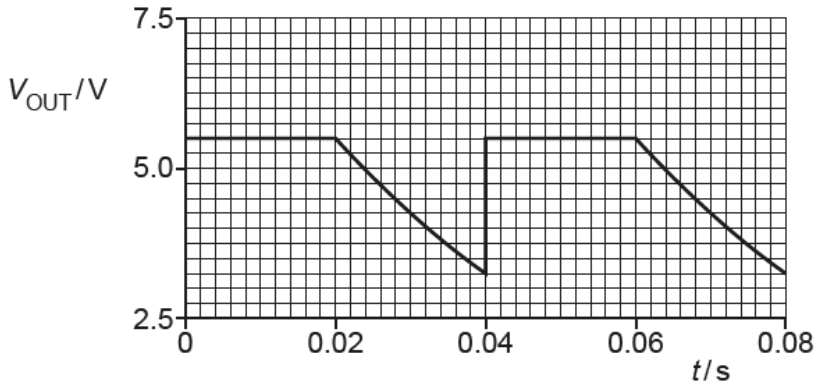


Fig. 5.3

(i) Determine the frequency of V_{IN}.

frequency = ... Hz [1]

(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]

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3. June/2023/Paper_9702/42/No.5

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

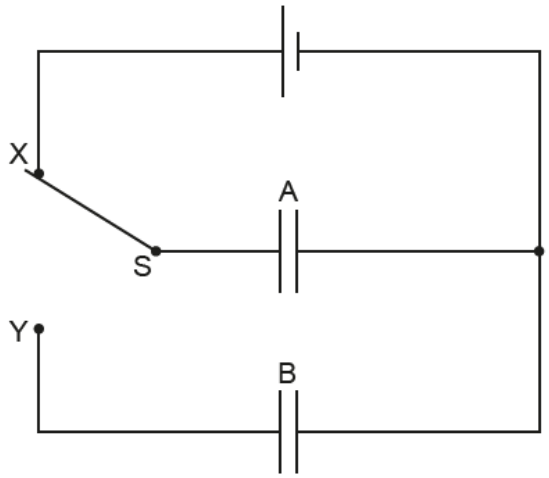


Fig. 5.1

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:

(i) the initial charge Q_A on the plates of capacitor A

Q_A = ... [1]

(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.

(i) State and explain what happens to the charge that was initially on the plates of capacitor A.

.....

.....

..... [2]

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(ii) Show that the final potential difference (p.d.) V_B across capacitor B is given by

$$V_B = \frac{V}{4}.$$

Explain your reasoning.

[3]

(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]

[Total: 9]

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4. March/2023/Paper_9702/42/No.5

A capacitor, a battery of electromotive force (e.m.f.) 12 V, a resistor R and a two-way switch are connected in the circuit shown in Fig. 5.1.

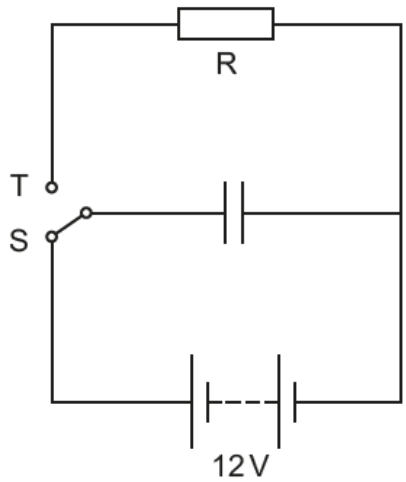


Fig. 5.1

The switch is initially in position S. When the capacitor is fully charged, the switch is moved to position T so that the capacitor discharges. At time t after the switch is moved the charge on the capacitor is Q.

The variation with t of $\ln(Q/\mu C)$ is shown in Fig. 5.2.

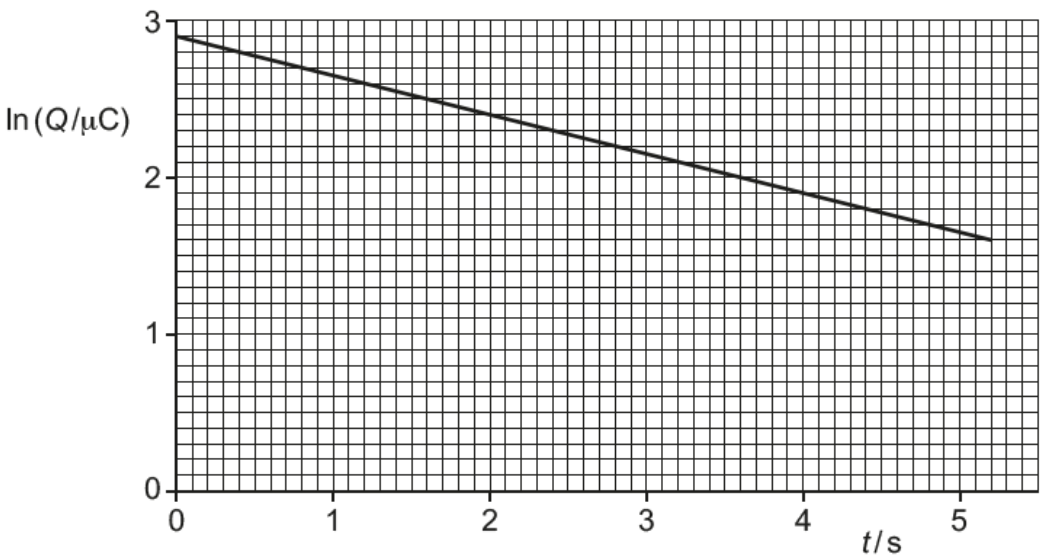


Fig. 5.2

(a) Show that the capacitance of the capacitor is 1.5 μF.

[3]

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(b) Determine the resistance of R.

resistance = ... Ω [3]

(c) Calculate the energy stored in the capacitor at time $t = 0$.

energy = ... J [2]

(d) A second identical resistor is now connected in parallel with R.

The switch is initially in position S. When the capacitor is fully charged, the switch is moved to position T so that the capacitor discharges. At time t after the switch is moved the charge on the capacitor is Q.

On Fig. 5.2, sketch a line to show the variation of $\ln(Q/\mu C)$ with t between time $t = 0$ and time $t = 5.0\,s$. [2]

[Total: 10]

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