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]

Use

Q2.

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

For Examin Use

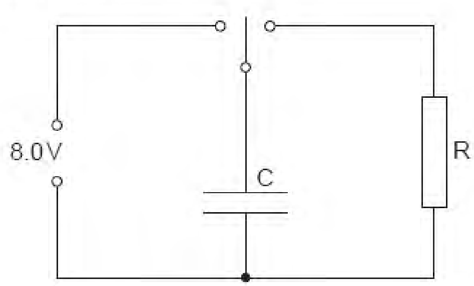

Fig. 5.1

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.

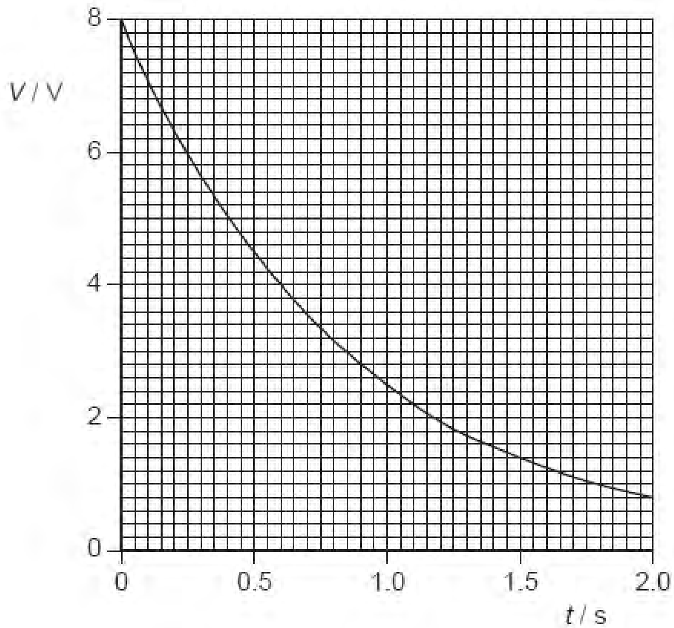

Fig. 5.2

(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.

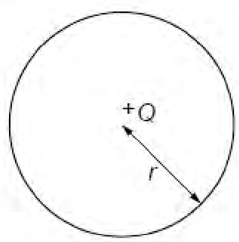

Fig. 5.1

(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.

Ex

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.

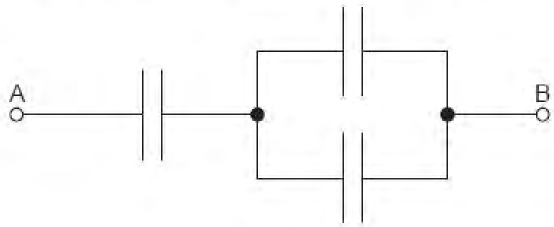

Fig. 5.1

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.

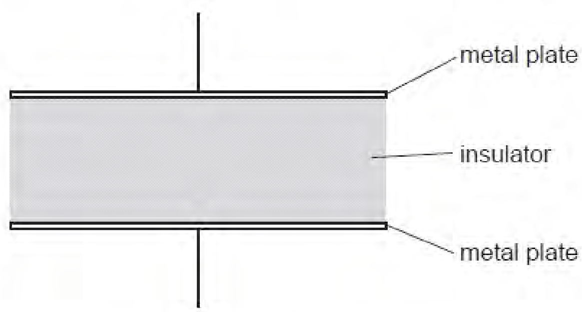

Fig. 3.1

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.

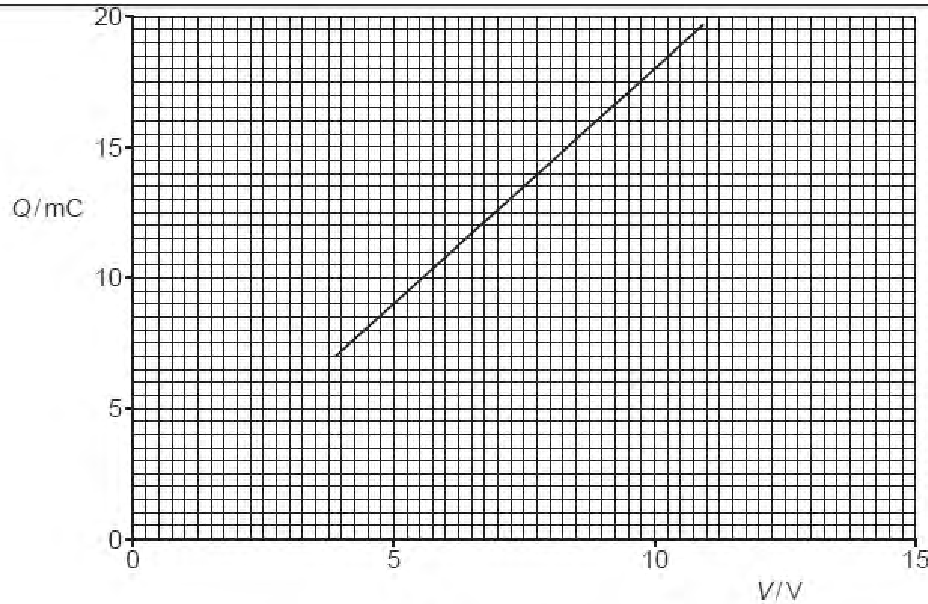

Fig. 3.2

(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 10.0 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.

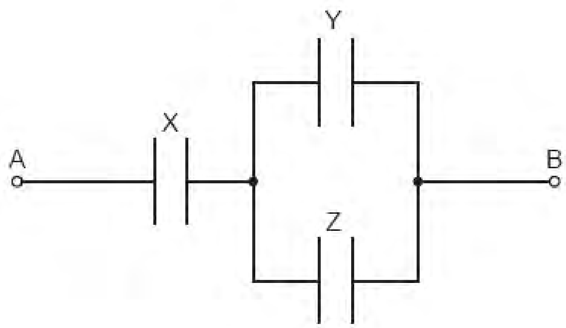

Fig. 3.3

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]

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.

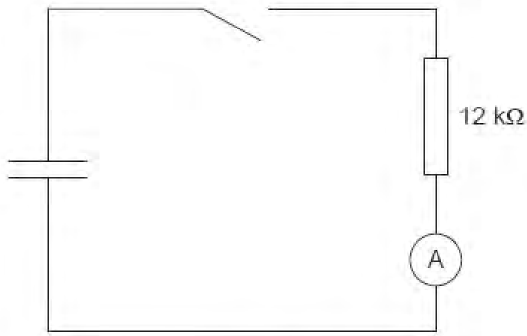

Fig. 5.1

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

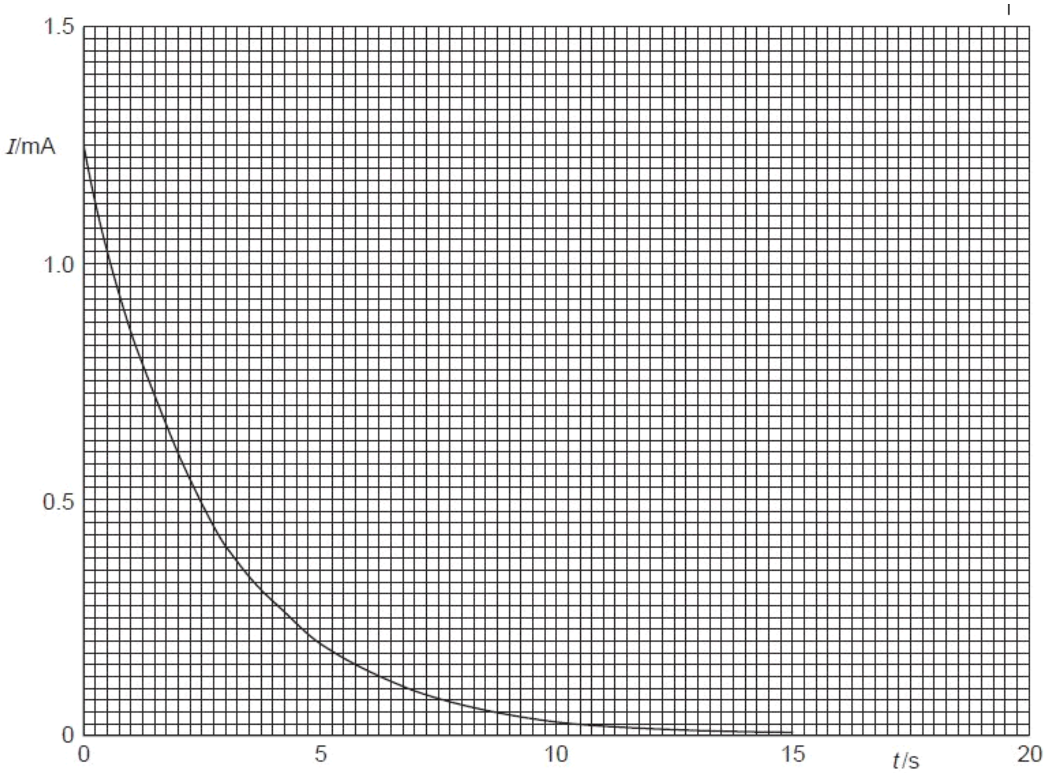

Fig. 5.2

(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 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]

Q8.

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

....

.... [1]

For Examiner's Use

(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*.

....

....[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 Examiner's 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.

....

....

.... [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.

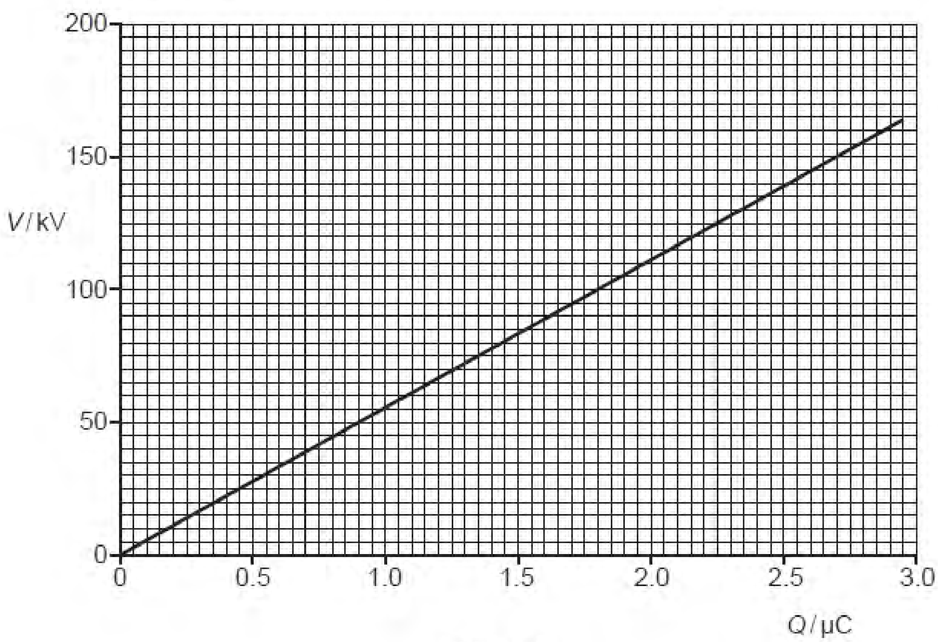

Fig. 4.1

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]

For Examiner's Use

(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.

For Examiner's Use

4 **(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.

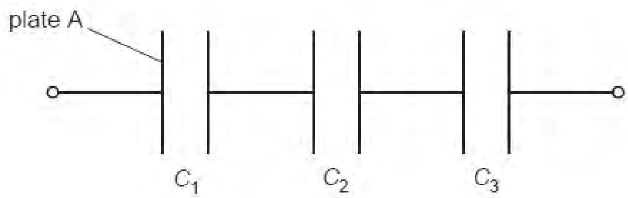

Fig. 4.1

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.

For Examiner's Use

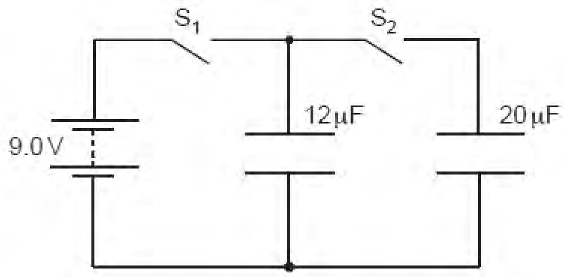

Fig. 4.2

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.

For Examiner's Use

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

....

....[1]

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

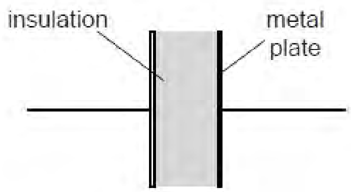

Fig. 5.1

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

....

....

....

....

....[4]

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

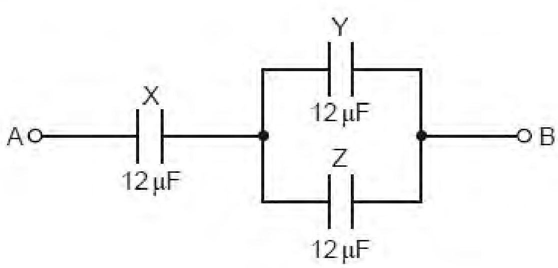

Fig. 5.2

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.

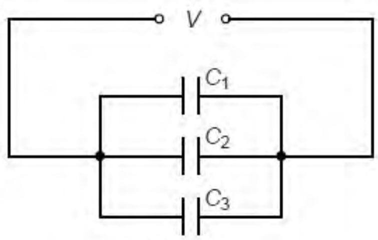

Fig. 4.1

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.

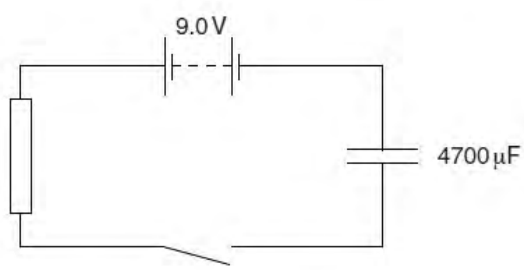

Fig. 6.1

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.

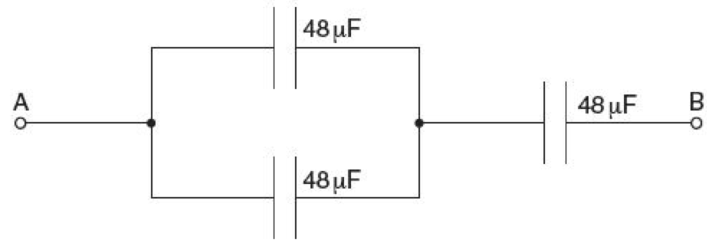

Fig. 6.1

(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]