Q1. The figure below shows a capacitor of capacitance 370 pF. It consists of two parallel metal plates of area 250 cm^2. A sheet of polythene that has a relative permittivity 2.3 completely fills the gap between the plates.

not to scale

(a) Calculate the thickness of the polythene sheet.

thickness = _____m

(2)

(b) The capacitor is charged so that there is a potential difference of 35 V between the plates. The charge on the capacitor is then 13 nC and the energy stored is 0.23 μJ.

The supply is now disconnected and the polythene sheet is pulled out from between the plates without discharging or altering the separation of the plates.

Show that the potential difference between the plates increases to about 80 V.

(2)

(c) Calculate the energy that is now stored by the capacitor.

energy stored = _____μJ

(2)

(d) Explain why there is an increase in the energy stored by the capacitor when the polythene sheet is pulled out from between the plates.

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(2)
(Total 8 marks)

Q2. Which of the following statements about a parallel plate capacitor is **incorrect**?

A The capacitance of the capacitor is the amount of charge stored by the capacitor when the pd across the plates is 1 V. ⬭

B A uniform electric field exists between the plates of the capacitor. ⬭

C The charge stored on the capacitor is inversely proportional to the pd across the plates. ⬭

D The energy stored when the capacitor is fully charged is proportional to the square of the pd across the plates. ⬭

(Total 1 mark)

Q3. (a) State the **three** factors upon which the capacitance of a parallel plate capacitor depends.

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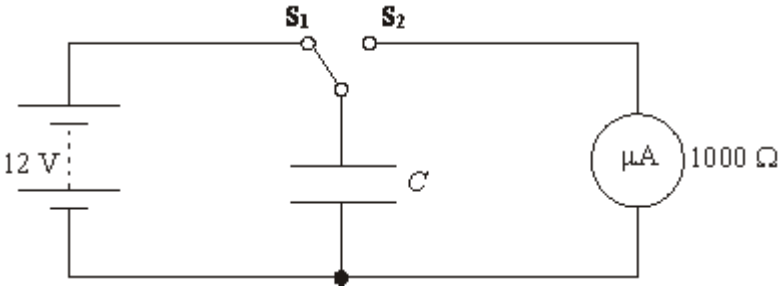
(2)

(b) The figure below shows a circuit for measuring the capacitance of a capacitor.



The switch is driven by a signal generator and oscillates between $\mathbf{S_1}$ and $\mathbf{S_2}$ with frequency *f*.

When the switch is in position $\mathbf{S_1}$ the capacitor charges until the potential difference across it is equal to the supply emf. When the switch moves to position $\mathbf{S_2}$ the capacitor discharges through the microammeter which has a resistance of 1000 Ω.

In one experiment a 0.047 μF capacitor is used with a 12 V supply.

(i) Calculate the charge stored by the capacitor when the switch is in position $\mathbf{S_1}$.

(ii) Calculate the time for which the switch must remain in contact with $\mathbf{S_2}$ in order for the charge on the capacitor to fall to 1% of its initial charge.

(iii) Assuming that the capacitor discharges all the stored charge through the microammeter, calculate the reading on the meter when the switch oscillates at 400 Hz.

(6)
(Total 8 marks)

Q4. The Earth's surface and the base of a charged cloud can be considered to be two plates of a parallel-plate capacitor.

(a) Calculate the capacitance of an Earth-cloud system when the base of the cloud has an area of 1.4×10^6 m^2 and is 800 m above the Earth's surface.

$\varepsilon_0 = 8.9 \times 10^{-12}$ F m^{-1}

ε_r for air = 1.0

(2)

(b) A potential difference of 3.0×10^6 V across each metre of air will cause the air to break down and allow the cloud to discharge to the Earth.

(i) Show that the average breakdown p.d. for the 800 m layer of air between the Earth and the base of the cloud is about 2.5×10^9 V.

(1)

(ii) Calculate the maximum energy that the charged Earth – cloud system can store.

(2)

(iii) Calculate the maximum charge stored by the system before breakdown commences.

(1)

(c) By considering the cloud discharge to be modelled by a resistor connected across a capacitor, calculate the resistance that would allow a cloud to discharge 99% of its charge to Earth in a time of 0.25 s.

(3)
(Total 9 marks)

Q5. (a) Explain what is meant by a capacitance of 1 farad (F).

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(1)

(b) A parallel plate capacitor was made from two circular metal plates with air between them.
The distance between the plates was 1.8 mm. The capacitance of this capacitor was found to be 2.3×10^{-11} F.

The permittivity of free space $\varepsilon_0 = 8.9 \times 10^{-12}$ F m^{-1}

The relative permittivity of air = 1.0

Calculate:

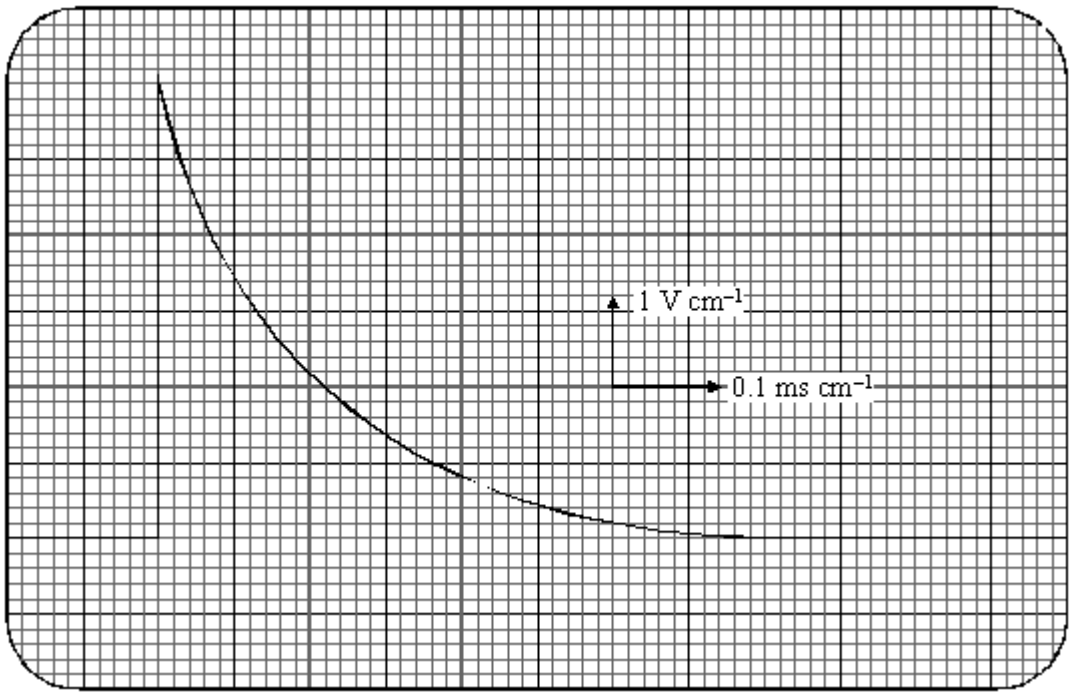
(i) the radius of the plates used in the capacitor;

(3)

(ii) the energy stored when the potential difference between the capacitor plates is 6.0 V.

(2)

(c) A student charged the capacitor and then tried to measure the potential difference between the plates using an oscilloscope. The student observed the trace shown in the diagram below and concluded that the capacitor was discharging through the oscilloscope.



Calculate the resistance of the oscilloscope.

(3)
(Total 9 marks)