11.3 Capacitance

Question Paper

Course	DP IB Physics
Section	11. Electromagnetic Induction (HL only)
Topic	11.3 Capacitance
Difficulty	Easy

Time allowed: 70

Score: /53

Percentage: /100

Question 1a

The capacitance of a capacitor including a dielectric material is given by the equation:

$$C = \varepsilon \frac{A}{d}$$

(a)
Determine the following variables and state an appropriate unit for each:

(i) ε

[1]

(ii) A

[1]

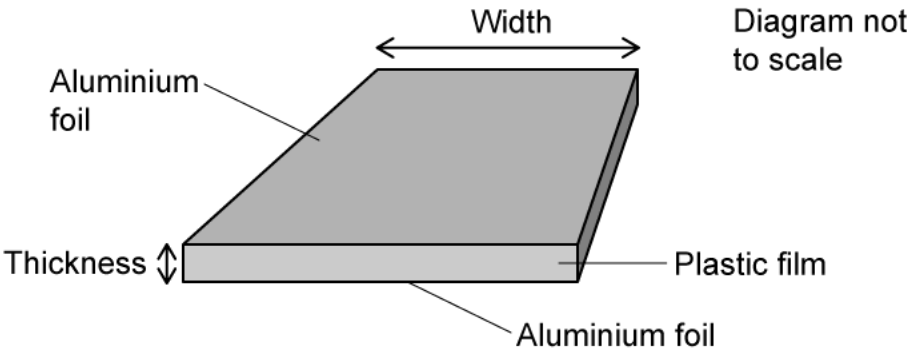
(iii) d

[1]

[3 marks]

Question 1b

A student makes a parallel-plate capacitor of capacitance 78 nF from aluminium foil and plastic film by inserting one sheet of plastic film between two sheets of aluminium foil.



The aluminium foil has an area of 0.28 m^2 and the plastic film has a permittivity of $2.5 \times 10^{-11}\ C^2\ N^{-1}\ m^{-2}$.

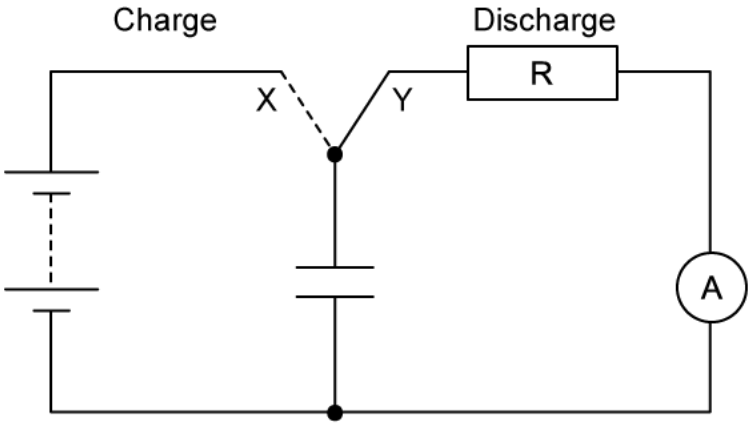
(b)
Calculate the thickness of the plastic film.

[4]

[4 marks]

Question 1c

The student uses a switch to charge and discharge the capacitor in the circuit shown. The ammeter is ideal.



The time constant of the capacitor is 0.24 ms.

(c)
Show that the resistance of resistor *R* is 3.1 kΩ.

[4]

[4 marks]

Question 1d

The emf of the battery is 15 V.

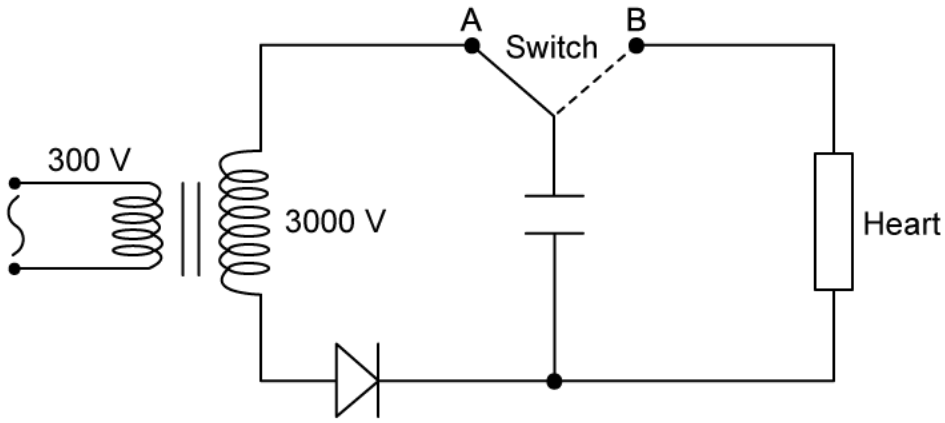
(d)
Calculate the initial charge of the capacitor before it is discharged.

[3]

[3 marks]

Question 2a

A defibrillator device sends an impulse of electrical energy to maintain a regular heartbeat in a person. The device is powered by an alternating current (ac) supply connected to a step-up transformer that charges a capacitor of capacitance 20 μF. The voltage in the circuit is 3000 V.



(a)
Calculate the maximum energy stored in the capacitor.

[3]

[3 marks]

Question 2b

(b)
Calculate the maximum charge, q stored in the capacitor.

[2]

[2 marks]

Question 2c

The current in the circuit passes through the diode from left to right following the direction of the triangle symbol.

(c)
Identify, by drawing a +, the positive plate of the capacitor.

[1]

[1 mark]

Question 2d

The switch is moved to position B.

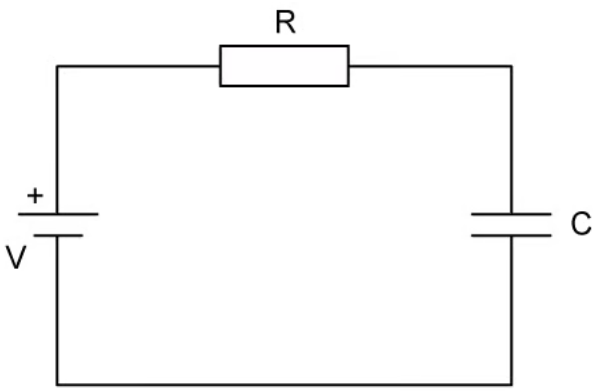
(d)
State what happens to the energy stored in the capacitor when the switch is moved to position B.

[1]

[1 mark]

Question 3a

A circuit containing a power supply *V*, a resistor *R* and a capacitor *C* is constructed in a laboratory.



(a)
Define the meaning of the time constant for a discharging capacitor.

[1]

[1 mark]

Question 3b

The resistor, *R* in the experiment is fixed at a resistance of 100 Ω and the capacitor, *C* has a capacitance of 25 μF and is discharging.

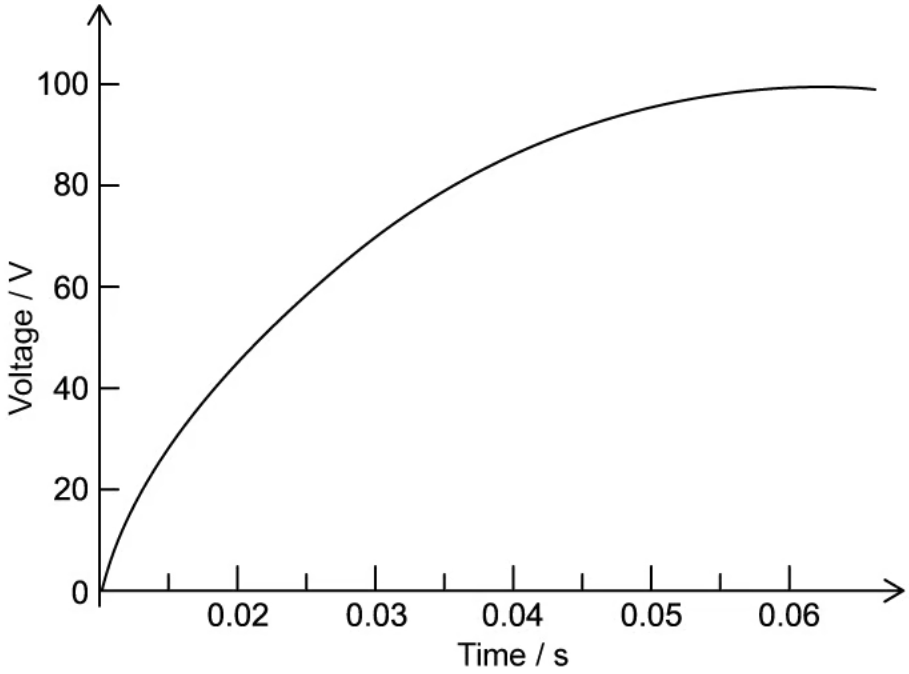
(b)
Calculate the time constant of the circuit.

[2]

[2 marks]

Question 3c

A different resistor and capacitor are now added to the circuit from (a). The capacitor is charging.



(c)

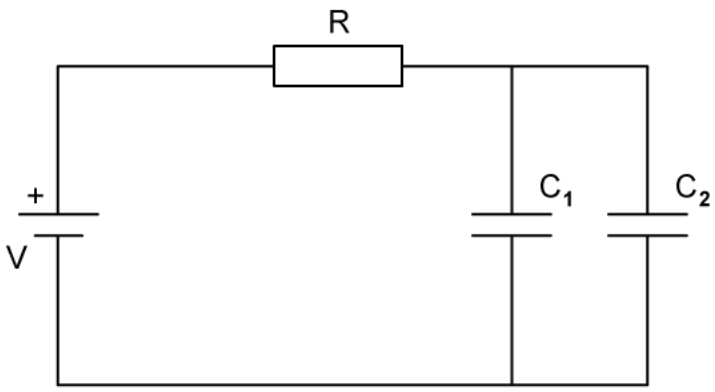
Use the graph to state the value of the time constant for this new circuit.

[2]

[2 marks]

Question 3d

An additional capacitor C_2 is added in parallel to the circuit.



(d)

State the effect on the charge stored in the circuit after adding this additional capacitor.

[1]

[1 mark]

Question 4a

(a)

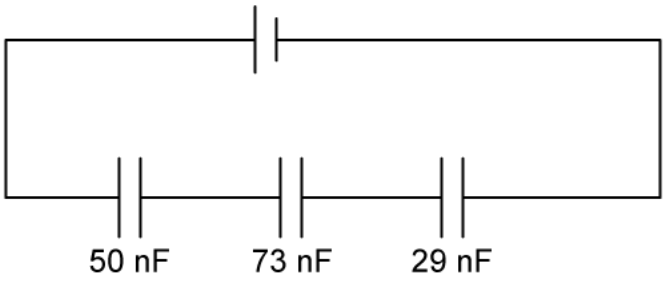
Define capacitance.

[1]

[1 mark]

Question 4b

Three capacitors are connected to a power supply.



(b)

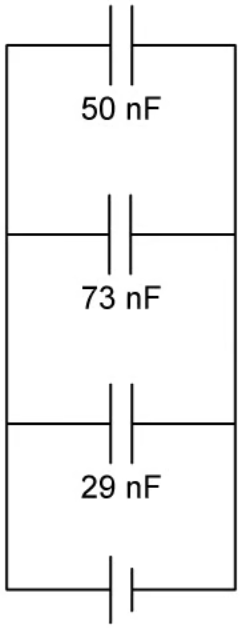
Calculate the combined capacitance in this circuit.

[3]

[3 marks]

Question 4c

The capacitors in part (b) are arranged into a parallel combination.



(c)
Determine the new total capacitance of the circuit.

[2]

[2 marks]

Question 4d

A parallel plate capacitor has plates of area 0.680 m^2, which are separated by a distance of 5.50 mm in a vacuum. The capacitor is connected to a dc source of potential difference 8.00 kV. :

(d)
Calculate

(i)
The capacitance of the capacitor.

[2]

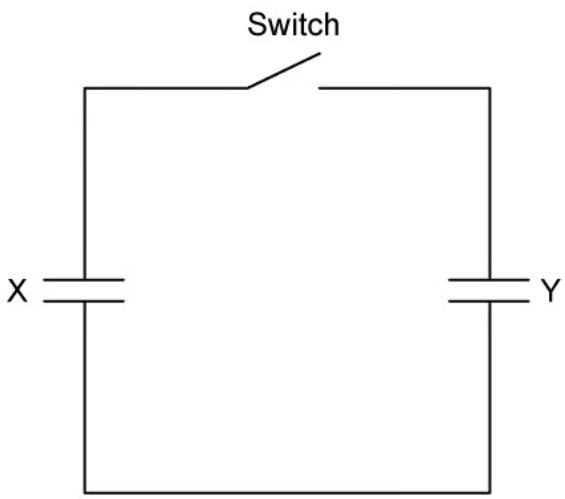
(ii)
The charge on one of the plates.

[3]

[5 marks]

Question 5a

The diagram shows two capacitors, X and Y, connected in a series circuit.



(a)
For the time after the switch is closed and when charge has stopped moving, write equations which would determine:

(i)
The initial and final values of charge on the capacitors in terms of q.

[1]

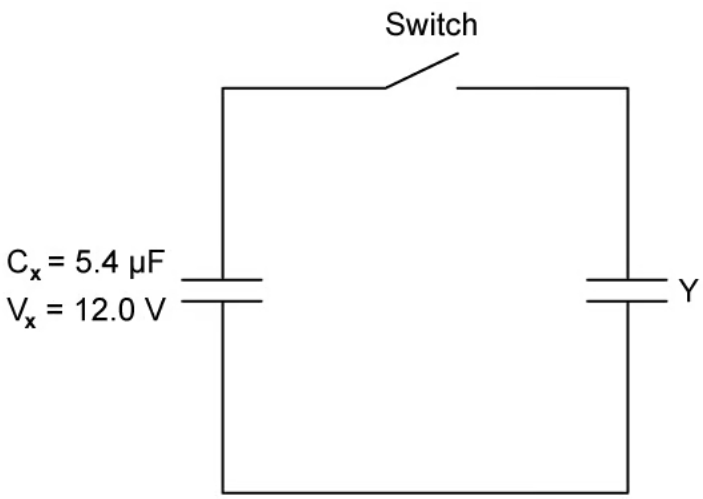
(ii)
The ratio of the final charges on the two capacitors, $\frac{q_X}{q_Y}$ in terms of q and C.

[3]

[4 marks]

Question 5b

Capacitor X has capacitance of 5.40 μF and has initially been charged by connecting it to a source of emf 12.0 V.



(b)
Using the equations from part (a) or otherwise, calculate the charge

(i)
Initially on capacitor X.

[2]

(ii)
Finally the total on both capacitors X and Y.

[1]

[3 marks]

Question 5c

Capacitor Y has capacitance C_Y and is initially uncharged.

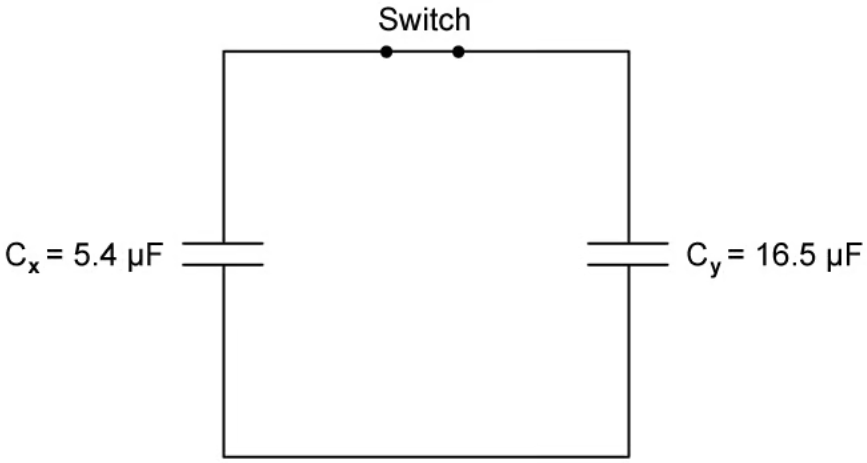
(c)
Using the two equations derived in part (a), find an expression in terms of q and C to determine the final values of the charges on each capacitor.

[3]

[3 marks]

Question 5d

The value of $C_Y = 16.5\ \mu F$.



(d)
Use this value to calculate the magnitudes of both charges, q_X and q_Y after the switch has closed and charge has stopped moving.

[5]

[5 marks]