Formulas

- $C = \frac{R}{k}$ ← capacitance on sphere, ← radius, k ← 9×10^9

charge

- $Q = CV$

capacitance

- $C_T = C_1 + C_2 \ldots$ (Parallel)

- $C_T = \left(\frac{1}{C_1} + \frac{1}{C_2} \ldots\right)^{-1}$ (series)

- $E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2} \times \frac{Q^2}{C}$

Energy stored in a capacitor

- $E = QV$

Energy transfered to a capacitor

- capacitance is the ratio of charge to potential for a conductor

  it is also the charge stored on one plate per unit p.d between the plates.

$C = \frac{Q}{V}$

unit is farad (F)

- A capacitor is a device that stores energy, by having 2 plates holding an opposite but equal charge with an insulator in between them, and work is being done in order to keep the charges from attracting.

  Thus

- capacitors are used for

  - storing energy
  - Smoothing

- Factors affecting capacitance
  - Material that plates are made of
  - Area of plates

$$C = \varepsilon_0 \frac{A}{d}$$

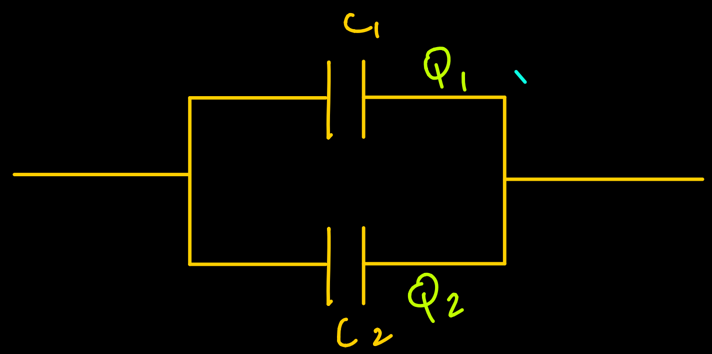
Area of 1 of the plates

distance between plates

$8.85 \times 10^{-12}\ F\ m^{-1}$

- Combined capacitances

  - Parallel (potential difference across capacitors is same)



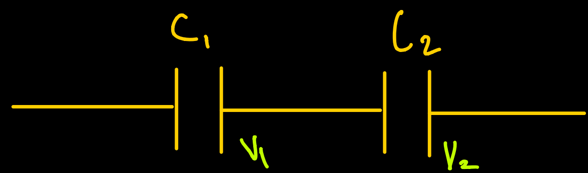
total Q (charge) is $Q_1 + Q_2$

$$Q_T = Q_1 + Q_2 \qquad (Q = CV)$$

$$C_T \cancel{V} = C_1 \cancel{V} + C_2 \cancel{V}$$

$$\therefore \; C_T = C_1 + C_2$$

- Series (charge across capacitors is same)



$$V_T = V_1 + V_2$$

$$\left(V = \frac{Q}{C}\right)$$

$$\frac{\cancel{Q}}{C_T} = \frac{\cancel{Q}}{C_1} + \frac{\cancel{Q}}{C_2}$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\therefore \quad C_T = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1}$$

Energy in a capacitor

- Energy is stored in a capacitor as electric potential energy

Energy = work done

electric potential is work done per unit charge

so:

$$V = \frac{W}{Q}$$

charge

$$E = W$$

$$\therefore \quad V = \frac{E}{Q}$$

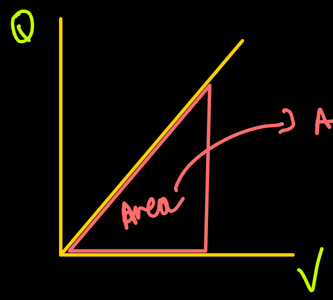
$$E = QV$$

This shows us the Energy is area under a QV graph.

Therefore, plotting a Q V graph from the equation Q = CV, we realise that $E = \frac{1}{2} QV$

$Q = CV$

$Q \propto V$



$\rightarrow$ Area = Energy = $\frac{1}{2} QV$

$\cdot\; Q = CV$ $\quad\cdot\; V = \frac{Q}{C}$

$\therefore\; E = \frac{1}{2}(CV) \times V$ or $E = \frac{1}{2} \times Q \times \left(\frac{Q}{C}\right)$

$E = \frac{1}{2} CV^2$ $\quad E = \frac{1}{2} \times \frac{Q^2}{C} = \frac{Q^2}{2C}$

$\therefore$ Energy stored inside a capacitor is

$E = \frac{1}{2} QV$ $\quad E = \frac{1}{2} \frac{Q^2}{C}$

$E = \frac{1}{2} CV^2$

• Energy transfered to a capacitor is

$$E = QV$$

voltage of the thing that is being used to charge it.

$Q = \frac{E}{V} = \frac{0.13}{5.6}$

• Energy stored inside the capacitor is less than the energy transfered to it because of resistances in wire

* Capacitance on sphere

$C = \frac{Q}{V}$ and $V = \frac{kQ}{r}$

subshere

$$C = \frac{\cancel{Q}}{\left(\frac{k\cancel{Q}}{r}\right)} = \frac{1}{1} \div \frac{k}{r} = \frac{r}{k} = 4\pi\varepsilon_0 R$$

Q1

$Q = CV$

$C = \frac{Q}{V}$

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

For Examiner's Use

$C = \frac{Q}{V}$

.... [1]

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

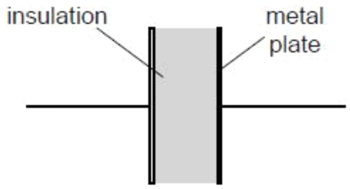


Fig. 5.1

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

because the plates have opposite but
equal charge, so net charge is zero.
however energy is stored because
work is being done by the insulation
in keeping the charges not attract each other. [4]

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

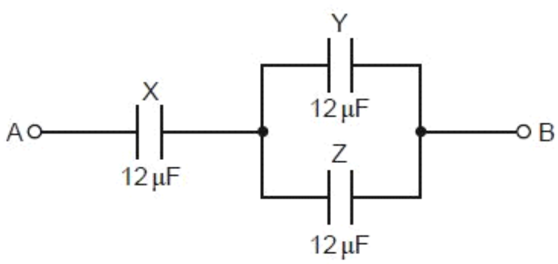


Fig. 5.2

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.

$\left(\frac{1}{24} + \frac{1}{12}\right)^{-1} = 8$

capacitance = 8 μF [2]

(ii) Explain why, when the potential difference of 9.0V is applied, the charge on one plate of capacitor X is 72 μC.

$q = CV$: $8 \times 10^{-6} \times 9$

$= 72\,\mu C$

[2]

(iii) Determine

1. the potential difference across capacitor X,

$V = \frac{q}{C} = \frac{72 \times 10^{-6}}{12 \times 10^{-6}} = 6$

potential difference = 6 V [1]

2. the charge on one plate of capacitor Y.

$q = CV$

$= 12 \times 10^{-6} \times 3$

charge = 36 μC [2]

Q2

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

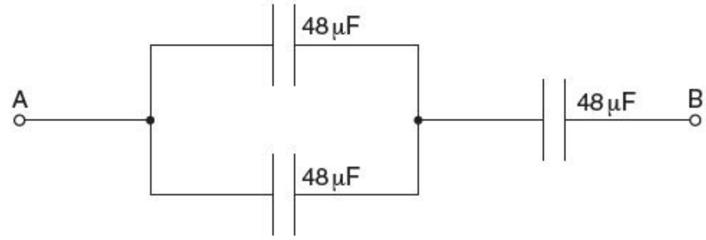


Fig. 6.1

(a) Calculate the total capacitance between points A and B.

$48 + 48 = 96$

$\left(\frac{1}{96} + \frac{1}{48}\right)^{-1} = 32$

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.

$q = CV$

$q = 48 \times 10^{-6} \times 6$

$= 2.88 \times 10^{-4}$

$V = \frac{q}{C} = \frac{2.88 \times 10^{-4}}{32 \times 10^{-6}}$

potential difference = ...9............................ V [2]