

Problem 1. (a) Determine the p.d. across a  $4\mu\text{F}$  capacitor when charged with  $5\text{mC}$   
 (b) Find the charge on a  $50\text{pF}$  capacitor when the voltage applied to it is  $2\text{kV}$ .

$$C = 4 \times 10^{-6} \text{ F}$$

$$Q = 5 \times 10^{-3} \text{ C}$$

$$Q = CV$$

$$V = \frac{Q}{C} = \frac{5 \times 10^{-3}}{4 \times 10^{-6}} = 1250 \text{ V or } 1.25 \text{ kV}$$

$$\text{ii) } C = 50 \times 10^{-12} \text{ F}$$

$$V = 2 \times 10^3 \text{ V}$$

$$Q = CV$$

$$Q = 50 \times 10^{-12} \times 2 \times 10^3 = 1 \times 10^{-7} \text{ or } 0.1 \times 10^{-6} \text{ C}$$

Problem 2. A direct current of  $4\text{A}$  flows into a previously uncharged  $20\mu\text{F}$  capacitor for  $3\text{ms}$ . Determine the p.d. between the plates.

Solution

$$I = 4 \text{ A}, C = 20 \times 10^{-6} \text{ F}$$

$$t = 3 \times 10^{-3} \text{ s}$$

$$V = \frac{Q}{C} = \frac{I \times t}{C}$$

$$V = \frac{4 \times 3 \times 10^{-3}}{20 \times 10^{-6}} = 6 \times 10^2 \text{ V or } 600 \text{ V}$$

Problem 3. A  $5\mu\text{F}$  capacitor is charged so that the p.d. between its plates is  $800\text{V}$ . Calculate how long the capacitor can provide an average discharge current of  $2\text{mA}$ .

Solution

$$C = 5 \times 10^{-6} \text{ F}$$

$$V = 800 \text{ V}$$

$$Q = CV$$

$$I \times t = CV$$

$$t = \frac{CV}{I} = \frac{5 \times 10^{-6} \times 800}{2 \times 10^{-3}} = 2 \text{ s}$$

Problem 4. Two parallel rectangular plates measuring  $20\text{cm}$  by  $40\text{cm}$  carry an electric charge of  $0.2\mu\text{C}$ . Calculate the electric flux density. If the plates are spaced  $5\text{mm}$  apart and the voltage between them is  $0.25\text{kV}$  determine the electric field strength.

Solution

$$A = 0.2 \text{ m} \times 0.4 \text{ m} = 8 \times 10^{-2} \text{ m}^2$$

$$Q = 0.2 \times 10^{-6} \text{ C}$$

determine the electric field strength.

$$Q = 0.2 \times 10^{-6} \text{ C}$$

$$D = \frac{Q}{A} = \frac{0.2 \times 10^{-6} \text{ C}}{8 \times 10^{-2} \text{ m}^2} = 2.5 \times 10^{-6} \text{ C/m}^2$$

$$E = \frac{V}{d} = \frac{0.25 \times 10^3 \text{ V}}{5 \times 10^{-3} \text{ m}} = 5 \times 10^4 \text{ V/m or } 50 \times 10^3 \text{ V/m}$$

Problem 5. The flux density between two plates separated by mica of relative permittivity 5 is  $2 \mu\text{C/m}^2$ . Find the voltage gradient between the plates.

Solution

$$D = 2 \times 10^{-6} \text{ C/m}^2$$

$$D = \epsilon E$$

$$\epsilon_r = 5$$

$$D = \epsilon E, E = \frac{D}{\epsilon} = \frac{D}{\epsilon_0 \epsilon_r} = \frac{2 \times 10^{-6}}{8.854 \times 10^{-12} \times 5} = 4.518 \times 10^4 \text{ V/m}$$

or  $45.2 \times 10^3 \text{ V/m}$

Problem 6. Two parallel plates having a p.d. of 200 V between them are spaced 0.8 mm apart. What is the electric field strength? Find also the electric flux density when the dielectric between the plates is (a) air, and (b) polythene of relative permittivity 2.3

Solution

$$V = 200 \text{ V}$$

$$d = 8 \times 10^{-4} \text{ m}$$

$$E = \frac{V}{d} = \frac{200}{8 \times 10^{-4}} = 2.5 \times 10^5 \text{ V/m or } 250 \text{ kV/m}$$

9)  $D = \epsilon E$  for air,  $\epsilon_r = 1$

$$D = \epsilon_0 \epsilon_r E = 8.854 \times 10^{-12} \times 1 \times 2.5 \times 10^5 = 2.2135 \times 10^{-6} \text{ C/m}^2$$

Problem 7. (a) A ceramic capacitor has an effective plate area of  $4 \text{ cm}^2$  separated by 0.1 mm of ceramic of relative permittivity 100. Calculate the capacitance of the capacitor in picofarads. (b) If the capacitor in part (a) is given a charge of  $1.2 \mu\text{C}$  what will be the p.d. between the plates?

Solution

$$A = 4 \times 10^{-4} \text{ m}^2$$

$$d = 1 \times 10^{-4} \text{ m}$$

$$\epsilon_r = 100$$

$$C = \frac{\epsilon A}{d} = \frac{\epsilon_0 \epsilon_r A}{d} = \frac{8.854 \times 10^{-12} \times 100 \times 4 \times 10^{-4}}{1 \times 10^{-4}} = 3540 \text{ pF}$$

b)  $V = \frac{Q}{C} = \frac{1.2 \times 10^{-6}}{3540 \times 10^{-12}} = 339 \text{ V}$

Problem 8. A waxed paper capacitor has two parallel plates, each of effective area  $800 \text{ cm}^2$ . If the capacitance of the capacitor

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

Problem 8. A waxed paper capacitor has two parallel plates, each of effective area  $800 \text{ cm}^2$ . If the capacitance of the capacitor is  $4425 \text{ pF}$  determine the effective thickness of the paper if its relative permittivity is 2.5

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

Problem 10. Calculate the equivalent capacitance of two capacitors of  $6 \mu\text{F}$  and  $4 \mu\text{F}$  connected (a) in parallel and (b) in series.

parallel capacitor

$$C_T = C_1 + C_2 \\ = 4 \mu\text{F} + 6 \mu\text{F} = 10 \mu\text{F}$$

Problem 11. What capacitance must be connected in series with a  $30 \mu\text{F}$  capacitor for the equivalent capacitance to be  $12 \mu\text{F}$ ?

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Problem 13. Capacitance's of  $3 \mu\text{F}$ ,  $6 \mu\text{F}$  and  $12 \mu\text{F}$  are connected in series across a  $350 \text{ V}$  supply. Calculate (a) the equivalent circuit capacitance, (b) the charge on each capacitor, and (c) the p.d. across each capacitor.

$$\frac{1}{C_T} = \frac{1}{3} + \frac{1}{6} + \frac{1}{12}$$

series capacitor

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

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

$$C_T = \frac{6 \times 10^{-6} \times 4 \times 10^{-6}}{10^{-6}(6+4)}$$

$$C_T = \frac{24 \times 10^{-12}}{10 \times 10^{-6}}$$

$$C_T = 2.4 \times 10^{-6} \text{ F}$$

Solution

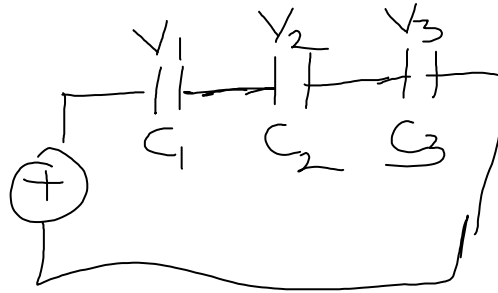
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_T} = \frac{C_2 C_3 + C_1 C_3 + C_1 C_2}{C_1 C_2 C_3}$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$C_T = \frac{C_1 C_2 C_3}{C_2 C_3 + C_1 C_3 + C_1 C_2} = 1.714 \mu F$$

$$Q = CV$$



$$b) Q = 1.714 \times 350 = 600 \mu C$$

$$c) V_1 = \frac{Q}{C_1} = \frac{600 \times 10^{-6}}{3 \times 10^{-6}} = 200 V$$

$$V_2 = \frac{Q}{C_2} = \frac{600 \times 10^{-6}}{6 \times 10^{-6}} = 100 V$$

$$V_3 = \frac{Q}{C_3} = \frac{600 \times 10^{-6}}{12 \times 10^{-6}} = 50 V$$

Problem 16. (a) Determine the energy stored in a  $3 \mu F$  capacitor when charged to  $400 V$  (b) Find also the average power developed if this energy is dissipated in a time of  $10 \mu s$ .

$$W = \frac{1}{2} QV \text{ or } \frac{1}{2} CV^2$$

$$W = \frac{1}{2} CV^2 = \frac{1}{2} \times 3 \times 10^{-6} \times 400^2$$

$$W = 0.24 J$$

$$b) P = \frac{\text{energy}}{\text{time}} = \frac{0.24}{10 \times 10^{-6}} = 24 K W$$