Assignment-2

ANSWER KEY

1. $k = v\_vac/v\_die \ = 200/30 = 4$

2. With air between the parallel plates,

$C_0 = \frac{g_0 A}{d} = 8PF$

With dielectric between the parallel plates

$$C = \frac{k\epsilon_0 A}{d\,/\,2} = 96PF$$

3. $C=C_3$ because the combination of C_1 and C_2 as well as C_4 and C_5 have been shorted.

4.(d) 5.(b) 6.(c) 7.(c) 8. (c) 9. (c)

MCQ

10. (b)

2 MARKS ANSWERS

11. Q a C so the charge will be divided in proportion of their capacitances. Explanation: When two charged conductors are touched together then the charge on them will get divided as we know charge can flow. We also know Q= CV.

12. (i) When switch S is open and dielectric is introduced, charge on each capacitor will be $q_1 = C_1 V$, $q_2 = C_2 V$

$q_1 = 5CV = 5 \times 2 \times 5 = 50\ \mu C$, $q_2 = 50\ \mu C$

Charge on each capacitor will become 5 times

(ii) P.d. across C_1 is still 5V and across C_2,

q = (5C) V

$$V' = \frac{V}{5} = \frac{5}{5} = 1V$$

13. A represents C_2 and B represents C_1

Reason: From the graph the slope q/v= Capacitance is greater for A. Also according to given conditions the capacitance CaA

so capacitance is larger for the C_2 because the area of its plates is large and d for the two capacitor is same. Hence, A represents C_2.

Let C be the capacitance of a capacitor

Given : $C_1 = C_2 = C_3 = C$ When connected in series: $C_s=C/3=1\mu F$ So $C=3\mu F$

When connected in parallel: Cp=C+C+C=3+3+3= 9μF

14. By introducing the metal plate between the plates of charged capacitor, the capacitance of capacitor increases. As $C=A\varepsilon_O/d-t(1-\frac{1}{K})$. For metal plate K is infinite so Obviously, effective separation between plates is decreased from d to (d – t)

15. 5 = C1 + C2............... (1st equation)

1.2 = C1C2/(C1 + C2)........ (2nd equation)

On solving we get C1 = 2mF and 3mF.

16. In the steady state, the displacement current and hence the conduction current, is zero as | |E→| | between the plates, is constant.

During charging and discharging, the displacement current and hence the conduction current is non zero as | |E→| | between the plates, is changing with time.

Current is non zero as | |E→| | between the plates, is changing with time.

17.a. The charge from one plate gets transferred to another plate through battery. The battery pumps the charge from one plate to another.

b. Yes size of plates does not matter.

3 MARKS ANSWERS

18. Given V_A= 90V, C_1 = 20μF, C_2 = 30μF and C_3= 15μF

Since these capacitors are connected in series, net capacitance will be

$$\frac{1}{c} = \frac{1}{20} + \frac{1}{30} + \frac{1}{15} = \frac{3}{20}$$

$$c = \frac{20}{3}\,\mu F$$

Carge on each capacitor q = CV =600μC

Potential difference across the capacitor C_2

$V_2 = \frac{q}{C_2} = \frac{600}{30} = 20v$

Energy stored in capacitor across C_2

E_2= 6000J

19. (i) Charge stored, Q = CV

300 μC = C × V ,

When potential is reduced by 100 V

$100\ \mu C = C(V - 100) = CV - 100\ C$

$100\ \mu C = 300\ \mu C - 100\ C$

$\Rightarrow 100\ C = 300\ \mu C - 100\ \mu C$

$\Rightarrow 100\ C = 200\ \mu C$

Therefore, capacitance $C = 2\mu F$

(ii) Charge stored when voltage applied is increased by 100 V

$Q' = 2\mu F \times (150 + 100) = 500\mu C$

20. $C = 20\mu F = 20 \times 10^{-6}$ F, V= 100 V , K= 5

Charge stored $Q= CV = 2000\mu C$

New value of capacitance $C' = 100\mu F$

Energy stored in a capacitor (E) $= \frac{Q^2}{2C}$

(i) Energy stored before dielectric is introduced

$E_1 = 0.1$ J

(ii) Energy stored after dielectric is introduced (no change in the value of Q)

$E_2 = 0.02$J

21. $C_{123} = 4\mu F$ (being in series)

$C_{eq} = C_{123} + C_4 = 16\mu F$

(i) $Q_1 = C_4 V = 6 \times 10^{-3}$

(ii) $Q_2 = C_{123} V = 2 \times 10^{-3}$ C

Charge on each of the capacitors $C_1, C_2, C_3 = 2 \times 10^{-3}$ C

22.Charge stored on the capacitor q=CV

When it is connected to the uncharged capacitor of same capacitance,

sharing of charge takes place between the two capacitor till the potential

of both the capacitor becomes $V/2$

Energy stored on the combination $(U_2) = \frac{1}{2} c \left(\frac{v}{2}\right)^2 + \frac{1}{z} c \left(\frac{v}{2}\right)^2 = \frac{cv^2}{4}$

Energy stored on single capacitor before connecting

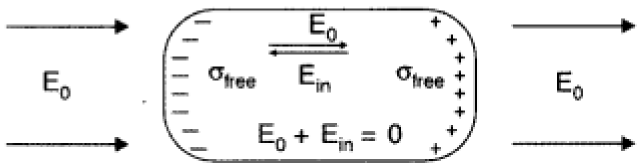
$U_1 = \frac{1}{2} Cv^2$

Ratio of energy stored in the combination to that in the single capacitor

$$\frac{U_z}{v_1} = \frac{cv^2/4}{cv^2/2} = 1:2$$

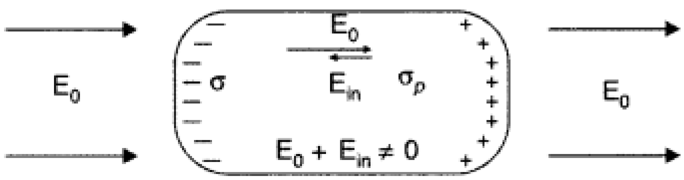
5 MARKS ANSWERS

22. (i) Behaviour of conductor in an external electric field :



Conductor

(ii) Behaviour of a dielectric in an external electrical field :



Dielectric

Explanation: In the presence of electric field, the free charge carriers in a conductor move the charge distribution and the conductor readjusts itself so that the net Electric field within the conductor becomes zero.

In a dielectric, the external electric field induces a net dipole moment, by stretching / reorienting the molecules. The electric field, due to this induced dipole moment, opposes, but does not exactly cancel the external electric field.

Polarisation: Induced Dipole moment, per unit volume, is called the polarisation. For Linear isotropic dielectrics having a susceptibility x_c, we have polarisation (p) as: $p = X_cE$

23. In first case C_1=εoKx(lxb)/d ....(i)

In second case, these two apartments are in parallel, their net capacity would be the sum of two individual capacitances

$C_2 = C'_2 + C''_2$

$$= \frac{\varepsilon_0 K_1\left(\frac{l}{2}\times b\right)}{d} + \frac{\varepsilon_0 K_2\left(\frac{l}{2}\times b\right)}{d}$$

$$\Rightarrow C_2 = 2\varepsilon_0 \frac{(l\times b)}{d}(K_1 + K_2) \qquad \ldots(ii)$$

Since these are identical capacitors, comparing (i) and (ii), We have $C_1 = C_2$

$$\frac{\varepsilon_0 K(l \times b)}{d} = \varepsilon_0 \frac{(l \times b)}{d}\left(\frac{K_1 + K_2}{2}\right)$$

$$\therefore \quad \mathbf{K = \frac{K_1 + K_2}{2}}$$

24.Given : d' = 3d, K = 10, C = ?, Q' = ?, U'_d= ?

(i) For parallel plate capacitor

$$C = \frac{\epsilon_0 A}{d}$$

Let the new capacity be C'

$$C' = \frac{K \epsilon_0 A}{d'} = \frac{10 \times (\epsilon_0 A)}{3d}$$

$$[\because K = 10, d' = 3d]$$

$$\Rightarrow \quad \left(\frac{10}{3}\right)\left(\frac{\epsilon_0 A}{d}\right) = \frac{10}{3}C$$

$$\Rightarrow \quad \mathbf{C' = \frac{10}{3}C}$$

(*ii*) Since V remains the same as the battery is not disconnected,

$$Q' = C'V$$

$$Q' = \left(\frac{10}{3}C\right)V = \frac{10}{3}CV = \frac{10}{3}Q$$

$$\Rightarrow \quad \mathbf{Q' = \frac{10}{3}Q}$$