(ii) Uniform electric field

(iii) Dipole

LONG ANSWER QUESTIONS (5 MARKS)

1. State the principle of Van de Graaff generator. Explain its working with the help of a neat labelled diagram.

2. Derive an expression for the strength of electric field intensity at a point on the axis of a uniformly charged circular coil of radius R carrying charge Q.

3. Derive an expression for potential at any point distant *r* from the centre O of dipole making an angle θ with the dipole.

4. Suppose that three points are set at equal distance r = 90 cm from the centre of a dipole, point A and B are on either side of the dipole on the axis (A closer to +ve charge and B closer to B) point C which is on the perpendicular bisector through the line joining the charges. What would be the electric potential due to the dipole of dipole moment 3.6 × 10^{-29} Cm at points A, B and C?

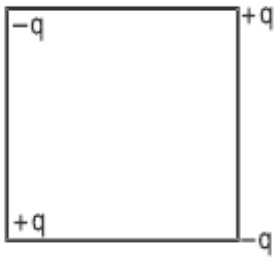
5. Derive an expression for capacitance of parallel plate capacitor with dielectric slab of thickness t(t<d) between the plates separated by distance d. How would the following (i) energy (ii) charge, (iii) potential be affected if dielectric slab is introduced with battery disconnected, (b) dielectric slab is introduced after the battery is connected.

6. Derive an expression for torque experienced by dipole placed in uniform electric field. Hence define electric dipole moment.

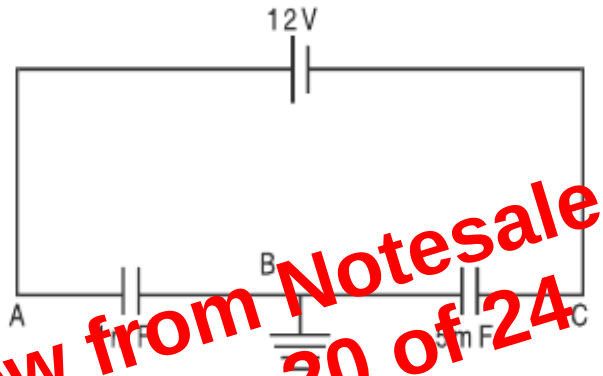
7. State Gauss's theorem. Derive an expression for the electric field due to a charged plane sheet. Find the potential difference between the plates of a parallel plate capacitor having surface density of charge 5 × 10^{-8} Cm^{-2} with the separation between plates being 4 mm.

8. Derive an expression for capacitance of parallel plate capacitor with dielectric slab of thickness t (t<d) between the plates separated by distance d. If the dielectric slab is introduced with the battery connected, then how do the following quantities change (i) charge (ii) potential (iii) capacitance (iv) energy.

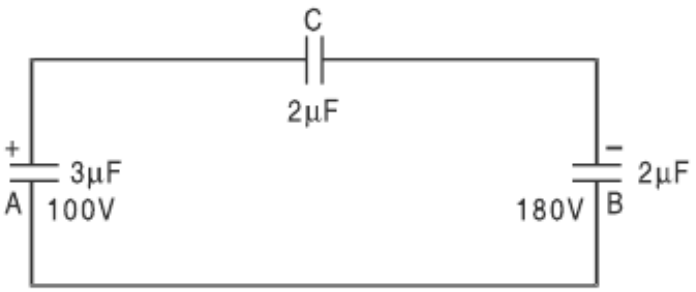
16. Four point charges are placed at the corners of the square of edge a as shown in the figure. Find the work done in disassembling the system of charges. $\left[\frac{kq^2}{a}(\sqrt{2}-4)\right]$ J



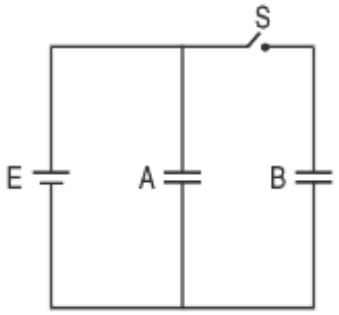
17. Find the potential at A and C in the following circuit :



18. Two capacitors A and B with capacitances 3 μF and 2 μF are charged 100 V and 180 V respectively. The capacitors are connected as shown in the diagram with the uncharged capacitor C. Calculate the (i) final charge on the three capacitors (ii) amount of electrostatic energy stored in the system before and after the completion of the circuit.



19. Two identical parallel plate capacitors connected to a battery with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with dielectric of dielectric constant 3. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of dielectric.

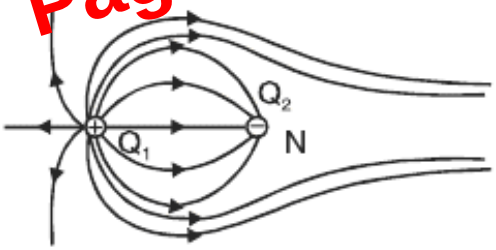


ANSWERS OF HOTS

1 MARK QUESTIONS

1. $(q_1 + q_3 - q_2 - q_6)/\epsilon_0$

3. $|Q_1| > |Q_2|$, N → Neutral point



2 MARKS QUESTIONS

4. In the capacitor the voltage increases from O to V, hence energy stored will correspond to average which will be ½ QV. While the source is at constant emf V. So energy supplied will be QV. The difference between the two goes as heat and em radiations.

15. $V_A = k\left[\frac{q_1}{a} + \frac{q_2}{b} + \frac{q_3}{c}\right]$

$= k\ 4\pi a\sigma - k\ 4\pi b\sigma + k\ 4\pi c\sigma$

$= 4\pi a\sigma\ (a - b + c)$

$= \frac{\sigma}{\varepsilon_0}(a - b + c)$

$V_B = k\left[\frac{q_1}{b} + \frac{q_2}{b} + \frac{q_3}{c}\right] = k\left[\frac{4\pi a^2\sigma}{b} - 4\pi kb\sigma + 4\pi kc\sigma\right]$

$= \frac{\sigma}{\varepsilon_0}\left(\frac{a^2}{b} - b^2 + c^2\right)$

$V_C = \frac{\sigma}{\varepsilon_0 c}\left(a^2 - b^2 + c^2\right)$

When $V_A = V_C$

$\frac{\sigma}{\varepsilon_0}(a - b + c) = \frac{\sigma}{\varepsilon_0 c}\left(a^2 - b^2 + c^2\right)$

$ac - bc + c^2 = a^2 - b^2 + c^2$

$c\ (a - b) = (a - b)\ (a + b)$

$c = a + b.$

17. $Q = CV$

Total charge Q = Total capacitance in series × voltage

$= \left(\frac{5}{6} \times 10^{-3}\right) \times 12 = 10 \times 10^{-3}$ coulomb

$V_{AB} = \frac{Q}{c_1} = \frac{10 \times 10^{-3}}{1 \times 10^{-3}} = 10V$