CBSE Test Paper-04

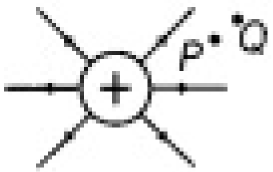
Class - 12 Physics (Electrostatic Potential and Capacitance)

1. The dielectric constant K of an insulator will be-
   a. 0.4
   b. 4
   c. -4
   d. 0
2. If a charge q_0 is there in a electric field caused by several point charges q_i The potential energy of q_0 is given by
   a. $\frac{1}{4\pi\epsilon_0}\sum\frac{q_i q_0}{r^2}$
   b. $\frac{1}{4\pi\epsilon_0}\sum\frac{q_i q_0}{r}$
   c. $\frac{1}{4\pi\epsilon_0}\sum\frac{q_i q_0}{r^3}$
   d. $\frac{1}{2\pi\epsilon_0}\sum\frac{q_i q_0}{r}$
3. For a parallel plate capacitor and a dielectric of dielectric constant K When a dielectric material is inserted between the plates while ____________ the potential difference between the plates decreases by a factor K
   a. the charge varies continously
   b. the charge is increased,
   c. the charge is decreased,
   d. the charge is kept constant,
4. An electrolytic capacitor is marked 8 $\mu\mathrm{F}$, 220 V. It can be used in a circuit where the p.d. across the capacitor may be
   a. 200 V
   b. 300 V
   c. 1000 V
   d. 500 V
5. Electric-field magnitude E at points inside and outside a positively charged spherical conductor having charge Q and a radius R are
   a. 0, $\frac{1}{4\pi\epsilon_0}\frac{Q}{R}$
   b. $\frac{1}{4\pi\epsilon_0}\frac{Q}{R^2}$
   c. less than 0, $\frac{1}{4\pi\in 0}\frac{q}{r^2}$ where r>R

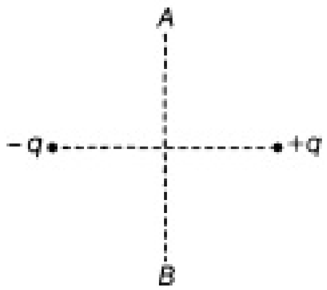
d. greater than 0, $\frac{1}{4\pi\epsilon_0}\frac{Q}{R^2}$

6. What is the work done in moving a test charge q through a distance of 1 cm along the equatorials axis of an electric dipole?

7. The figure shows the field lines of a positive charge. Is the work done by the field in moving a small positive charge from Q to P positive or negative?



8. A charge q is moved from a point A above a dipole of dipole moment p to a point B below the dipole in equatorial plane without acceleration. Find the work done in this process.



9. The discharging current in the atmosphere due to the small conductivity of air is known to be 1800 A on an average over the globe. Why then does the atmosphere not discharge itself completely in due course and become electrically neutral? In other words, what keeps the atmosphere charged?

10. Guess a possible reason why water has a much greater dielectric constant (=80) than say, mica (=6).

11. A parallel plate capacitor with air between the plates has a capacitance of 8 pF (1 pF = 10^{-12}F). What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a substance of dielectric constant 6?

12. What is an equipotential surface?A uniform electric field $\vec{E}$ of $300NC^{-1}$ is directed along PQ. A, B and C are three points in the field having x and y coordinates (in metres) as shown in the figure, calculate potential difference between the points.(i) A

and B (ii) B and C

13. Two charges $2\mu C$ and $-2\mu C$ are placed at points A and B, 6 cm apart.
    a. Identify an equipotential surface of the system.
    b. What is the direction of electric field at every point on this surface?
14. i. Write two characteristics of equipotential surfaces.
    ii. Draw the equipotential surfaces due to an electric dipole.

15. Two charged conducting spheres of radii a and b are connected to each other by a wire. What is the ratio of electric fields at the surfaces of the two spheres? Use the result obtained to explain why charge density on the sharp and pointed ends of a conductor is higher than on its flatter portions.

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Answers

1. b. 4

   Explanation: Dielectric constant of air is 1. All dielectrics generally have a value of the dielectric constant greater than 1.

   $K = \frac{F}{F_m}$

   where Fm is the force between two charged particles in a medium of dielectric constant K and F is the force between the two charges when placed in air.The force between two charges is greatest in air or vacuum and it decreases when any medium is placed between the charges. K cannot have negative, fractional or zero values.

2. b. $\frac{1}{4\pi\epsilon_0}\sum\frac{q_iq_0}{r}$

   Explanation: Potential energy of charge q_0 placed at a distance r_1 in a field created by a single charge q_1 is

   $\mho_1 = \frac{q_1q_0}{4\pi\varepsilon_0 r_1}$

   In a field created by multiple charges q_1, q_2,q_3,...q_i the potential energy of the charge q_0 is the scaler sum of potential energies due to each of the charges q_1, q_2, q_3,...q_i. As electrostatic potential energy is a scaler quantity. Thus

   The total potential energy of the charge q0 is $\mho = \sum_1^i \frac{q_iq_0}{4\pi\varepsilon_0 r_i}$

3. d. the charge is kept constant,

   Explanation: When a dielectric material is introduced in between the plates of a charged capacitor, which is disconnected from the battery, the charge remains constant, while the potential decreases by a factor K. The charge on the plates will increase if the dielectric material is slipped in between the plates of a capacitor which remain connected to the battery. In this case, the potential across the plates of the capacitor remains constant being equal to the battery voltage.

4. a. 200 V

Explanation: The break down potential of the capacitor is 220 V. In order to prevent damage to a capacitor, it should be always used in a circuit where the p.d is less than its break down potential. The p.d difference can only be 200 V.

5. c. less than 0, $\frac{1}{4\pi\in0}, \frac{q}{r^2}$ where r>R

Explanation: As in a conductor charge always reside on surface thus inside the conductor field will be zero. At outside the sphere field will be just as due to a point charge.

6. As $V_{eq} = 0$

Work done in moving a positive test charge q through a distance 1 cm is:

$W = qV = q \times 0 = 0$

7. Negative; As the charge is displaced against the force exerted by the field.

8. Electrostatic potential, V $\propto$ charge/distance. Now here both A and B point are at same distances (say r) from both the charges. So potential at the two points, $V_A = V_B$ = ($\frac{+q}{r} + \frac{-q}{r} = 0$). Hence work done =q($V_A$ - V_B) = 0.

9. Thunderstorms and ground lightning all over the globe charge the atmosphere continually and discharged through regions of ordinary weather. The two opposing currents are, on an average in equilibrium.

10. Water has a much greater dielectric constant than mica because of the high degree of association of water molecules each of which has a permanent dipole moment of about $0.6 \times 10^{-29} cm.$

11. $C_0 = \frac{\varepsilon_0 A}{d}$ or $\frac{\varepsilon_0 A}{d} = 8 \times 10^{-12}$

If the distance is reduced to half i.e. d/2 and space between the plates is filled by a substance of k = 6.

C = kC_0

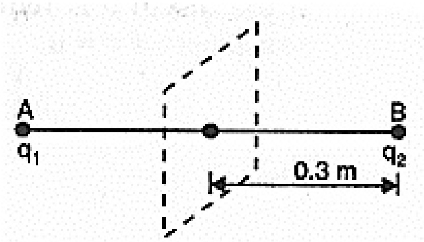
Then, $C = \frac{k\varepsilon_0 \cdot A}{d/2}$

$= \frac{2k(\varepsilon_0 A)}{d}$

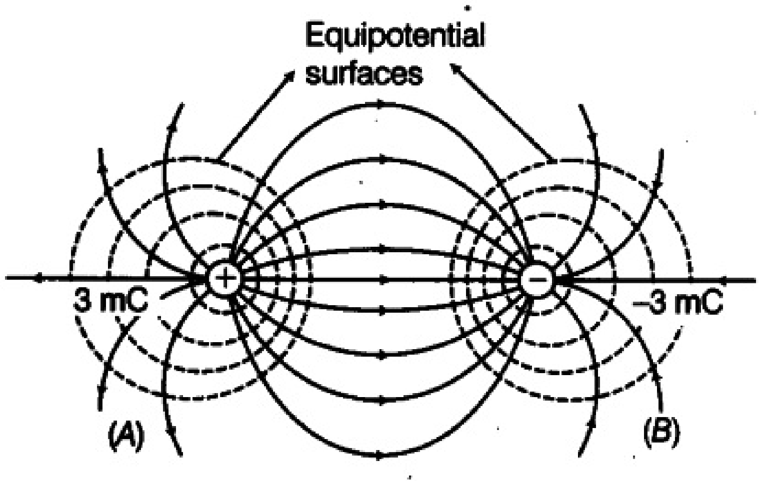
$= 2 \times 6 \times 8 \times 10^{-12}$

$= 96 \times 10^{-12} F$

or C = 96 pF

12. Equipotential surface is defined as a surface that has same electric potential at its every point.
    i. No work is done in taking a + ve charge from A to B because the charge moves perpendicular to the electric field.
    ∴ Potential difference between A and B = 0
    ii. Since $E=-\frac{\Delta V}{\Delta x}$
    Potential difference between B and C
    $\Delta V=-E\Delta x$
    $=-300\times 7=-2100V$
13. Given, $q1=2\mu C=2\times 10^{-6}Cq_2=-2\mu C=-2\times 10^{-6}C$
    a. Potential will be zero due to both charges at equipotential surface
    

    $\frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{x}+\frac{q_2}{(0.06-x)}\right]=0$
    or $\frac{q_1}{x}=-\frac{q_2}{(0.06-x)}$
    or $\frac{2\times 10^{-6}}{x}=\frac{(-2\times 10^{-6})}{[(0.06)-x]}$
    or x = 0.06 - x
    $x=\frac{0.06}{2}=0.03m$
    i.e. the plane normal to AB and passing through its mid point has zero potential everywhere.
    b. The direction of electric field is normal to the plane in the AB direction.
14. i. a. Two equipotential surfaces do not intersect each other as normals at the point of intersection on two surfaces will give two different directions of same electric field which is impossible.
    b. Closely spaced equipotential surfaces represent strong electric field and vice-versa.
    ii. Equipotential surfaces of an electric dipole having charges +3 mC and -3 mC are shown below



15. Suppose that two connected conducting spheres of radii a and b possess charges $q_1$and $q_2$respectively. On the surface of the two spheres, the potential will be

$V_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{a}$
$V_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{b}$

Till the potentials of two conductors become equal the flow of charges continue.

$V_1 = V_2$

or $\frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{a} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{b}$
or $\frac{q_1}{q_2} = \frac{a}{b}$

Now, the electric field on the two spheres is given as

$E_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{a^2}$
$E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{b^2}$
or $\frac{E_1}{E_2} = \frac{q_1}{q_2} \cdot \frac{b^2}{a^2} = \frac{a}{b} \cdot \frac{b^2}{a^2} = \frac{b}{a}$

Therefore, b : a is the ratio of the electric field of the first sphere to that of the second sphere. The surface charge densities of the two spheres are given as

$\sigma_1 = \frac{q_1}{4\pi a^2}$ (As the charges are distributed uniformly over the surfaces of conducting spheres)

$\sigma_2 = \frac{q_2}{4\pi b^2}$
$\therefore \frac{\sigma_1}{\sigma_2} = \frac{q_1}{q_2} \cdot \frac{b^2}{a^2} = \frac{a}{b} \cdot \frac{b^2}{a^2} = \frac{b}{a}$

Therefore, the surface charge densities are inversely related with the radii of the sphere. The surface charge density on the sharp and pointed ends of a conductor is higher than on its flatter portion since a flat portion may be taken as a spherical surface of large radius and a pointed portion as that of small radius.