CHAPTER NO. 12 (ELECTROSTATICS)

Question 12.1:- The potential is constant throughout a given region of space. Is the electrical field zero or non-zero in this region? Explain.

Answer:- If potential is constant throughout a given region of space, electric field will be zero in this region. We know that electric field is given as **E = -** $\frac{\Delta V}{\Delta r}$**.**

Given that electric potential = V = Constant, $\Delta V = 0$, $E = -(0/\Delta r) = 0$.

(Hint:- We know that electric field through a given region of space is defined as the negative of the potential gradient, where negative sign indicates that electric field always points out in the direction of decreasing potential. In the instant case, no such direction exists where electric potential is decreasing as potential is constant throughout this given region of space, hence no electric field**).**

Question 12.2:- Suppose that you follow an electric field line due to a positive point charge. Do electric field and the potential increase or decrease?

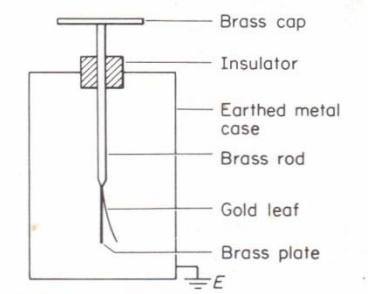
Answer:- Electric field lines due to a positive point charge always point radially outwards. If we follow an electric field line due to a positive charge, we will move away from the charge i.e. distance from the point charge will increase & electric field E and electric potential V will decrease.

We know that electric field E and electric potential V due to a positive point charge are given as:-

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2} \ \& \ \mathbf{V} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$$

It is evident that electric field is inversely proportional to the square of distance from the point charge and electric potential is inversely proportional to the distance from the point charge.

Question 12.3:- How can you identify which plate of the capacitor is positively charged?

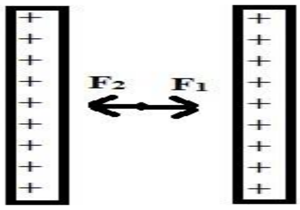


Gold-leaf electroscope

Answer:- A gold leaf electroscope is an electric instrument which is used to detect presence of electric charge on an object. Its construction is as shown in the given figure. Gold leaf of the electroscope is made positive. When positively charged plate of the capacitor is brought near the brass cap (disc), it induces a negative charge on the surface of brass disc, thus giving an excess positive charge to bottom of brass rod, therefore gold leaf is repelled away from the rod and its divergence increases.

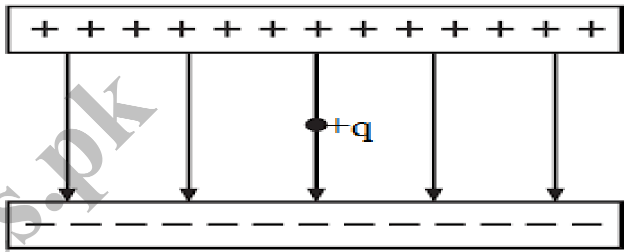
Question 12.4:- Describe the force or forces on a positive point charge when placed between parallel plates (a) with similar and equal charges (b) with opposite and equal charges.

Answer:- (a) When a positive point charge is placed between two parallel plates with similar and equal charge, both plates will apply equal and opposite forces on the point charge. The net force on the point charge will be zero. $F_{NET} = F_1 + F_2 = 0$ as $F_1 = - F_2$.



(a)

(b) When a positive point charge is placed between two parallel plates with opposite and equal charge, positive plates will repel it away from itself while negative plate will attract it towards itself. The net force on the point charge will be non-zero. $F_{NET} = F_1 + F_2 \neq 0$.



(b)

Question 12.5:- Electric lines of force never cross. Why?

Answer:- We know that electric field is the force experienced by a unit positive charge. It means that electric field is vector quantity. Therefore, electric lines of force never cross each other because at a given point in space, electric field must be a single valued and unidirectional quantity. If electric lines of force cross at a point, electric field would have more than one value and direction at that point, which is not possible.

Question 12.6:- If a point charge q of mass m is released in a non-uniform electric field with field lines pointing in the same direction, will it make a rectilinear motion?

Answer:- Electric field line is the path followed by a positive point charge in an electric field. It is stated that all the electric lines of force are pointing in the same direction so when a point charge q of mass m is released in a non-uniform electric field with the field lines pointing in the same direction, the charge will execute rectilinear motion.

(Hint:- We can visualize such non-uniform electric field by plotting several electric lines of force which are parallel but not equidistant**).**

Question 12.7:- Is E necessarily zero inside a charged rubber balloon if balloon is spherical? Assume that charge is distributed uniformly over the surface.

Answer:- Yes, electric field is necessarily zero inside a charged rubber balloon.

According to Gauss's law, electric flux through any closed surface is $1/\varepsilon_o$ times the total charge enclosed by the surface. Mathematically, $\boldsymbol{\phi_e = q/\varepsilon_o}$**.**

In the given case, charge enclosed inside the rubber balloon is zero as all the charge is distributed uniformly over the surface of the balloon.

$\phi_e = q/\varepsilon_o$, $\phi_e = \vec{E} \cdot \vec{A} = E\,A \cos\theta = 0/\varepsilon_o = 0$.

In case of spherical surface (balloon), $\theta = 0^o$ so we can say that $E\,A = 0$

As $A \neq 0$ so $E = 0$.

Question 12.8:- Is it true that Gauss's law states that the total number of lines of forces crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within the surface?

Answer:- We know that electric flux is the total number of electric lines of force crossing any closed surface in the outward direction. According to Gauss's law, electric flux through any closed surface is $1/\varepsilon_o$ times the total charge enclosed by the surface. Mathematically, $\boldsymbol{\phi_e = q/\varepsilon_o}$ so $\boldsymbol{\phi_e \propto q}$**.** We can say that Gauss's law states that the total number of lines of forces crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within the surface. Hence, the given statement is true.

Question 12.9:- Do electrons tend to go to region of high potential or of low potential?

Answer:- Electrons always tend to go to the region of high potential (positive charge) from the region of low potential (negative charge) because electrons are negatively charged particles. Coulomb's force always forces electron to move from region of low potential to the region of high potential.