BYJU'S Study Planner for Board Term I
(CBSE Grade 12)

Date: 09/11/2021

Subject: Physics

Topic : Electrostatics   Class: Standard XII

1. If a charged body is placed near a neutral conductor, then

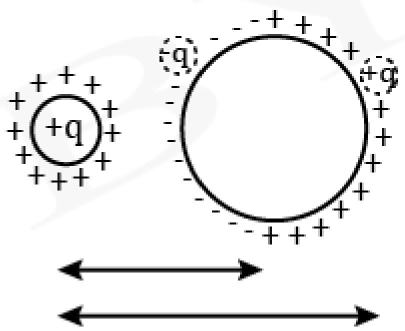
   A. It will repel the conductor

   B. It will attract the conductor ✔

   C. It will not exert either attractive or repulsive force on conductor

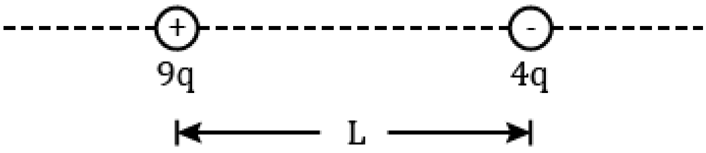
   D. It may repel or attract conductor, depending on its shape

When the charged body is placed in vicinity of the neutral conductor, it will induce opposite charge on the surface facing it. This happens due to induction.



⇒ In order to maintain the conductor neutral, exactly equal amount of opposite charge will appear on the opposite surface of the conductor. Thus attractive forces will dominate and charged body will attract the conductor.

2. For the given system of charges, where should a third charge $+16q$ be placed from negative charge, so that third charge experiences no net force?



A. $\frac{L}{2}$

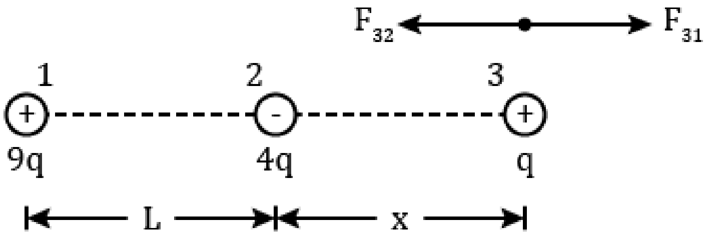
B. L

C. $2L$ ✓

D. $3L$

Since, third charge is positive in nature and experiences no net force, so $+q$ charge should be placed on the line joining of given two charges and right side of $-4q$ charge (smaller magnitude charge).

Let x be the distance between $-4q$ and $+q$.



So, Net force on charge

$+q = 0$

$\therefore \ |\vec{F}_{31}| = |\vec{F}_{32}|$

$$\Rightarrow \frac{k(9q)(16q)}{(L+x)^2} = \frac{k(4q)(16q)}{x^2}$$

$$\Rightarrow \left(\frac{x}{L+x}\right)^2 = \frac{4}{9}$$

$$\Rightarrow \frac{x}{L+x} = \pm\frac{2}{3}$$

$$\Rightarrow 2L + 2x = \pm 3x$$

$$\Rightarrow x = 2L \text{ or } -\frac{2L}{5}$$

$\because \ x = -\frac{2L}{5}$ (Not possible)

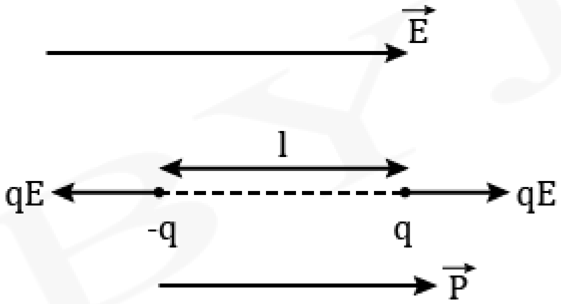
$\therefore \ x = 2L$

Hence, option (c) is the correct answer.

3. An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in a uniform electric field E. If its dipole moment is along the direction of the field, the net force acting on it and its potential energy are respectively

- **A.** $2qE$ and minimum
- **B.** qE and pE
- **C.** Zero and minimum (correct)
- **D.** qE and maximum

As shown in figure, the dipole is placed in uniform electric field in the direction of $\vec{E}$.



The net force on dipole is

$F_{net} = F_{q^+} + F_{q^-}$

$\Rightarrow F_{net} = qE - qE = 0$

The angle between $\vec{p}$ and $\vec{E}$ is 0°. So, potential energy is given as

$U = -\vec{p}.\vec{E} = -pE\cos 0^\circ$

$\Rightarrow U = -pE$

It repents the maximum negative potential energy of dipole.

$\therefore U$ is minimum.

Hence, option (c) is correct.

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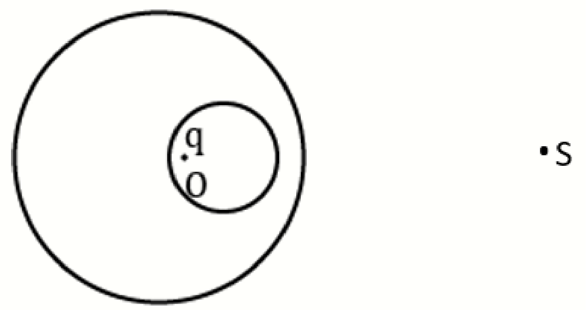
4. A charge q is placed at point O in a cavity in a spherical uncharged conductor. Point S is outside the conductor. If q is displaced from O towards S such that it is still inside the cavity, then electric field at S will



✗ **A.** increase

✗ **B.** decrease

✗ **C.** first increase and then decrease

✓ **D.** remains unchanged

The spherical uncharged conductor will show electrostatic shielding and will not allow electric field lines from charge q to penetrate it. Thus, there will be no effect of electric field due to q at point S. Hence, even on moving the charge inside the cavity the electric field at S will remain uncharged.

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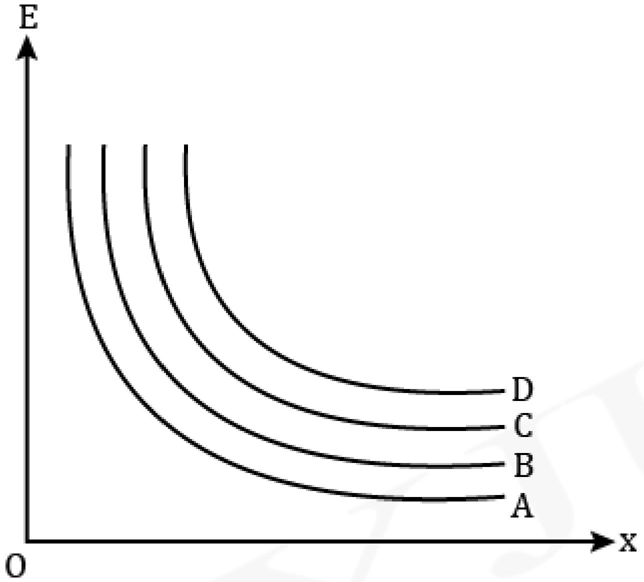
5. Given graph shows electric field intensity due to a point charge (E) at a distance (x) from it.
Here graphs(A, B, C, D) corresponding to four charges are shown. Which graph represents the charge of higher magnitude?

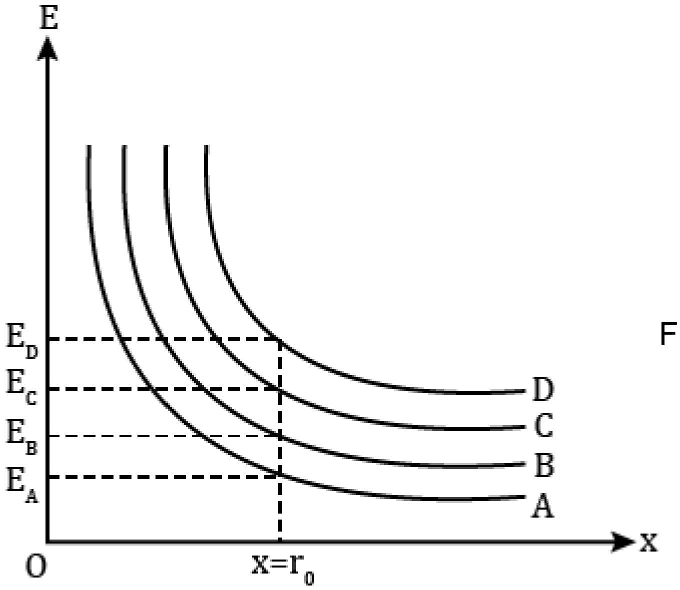


A. A

B. B

C. C

D. D ✔



From the definition of intensity of electric field,

$$E = k\frac{Q}{r^2}$$

So, if r is constant.

$$E \propto Q \quad .....(1)$$

For the given curves, at $x = r_0$, we can see that,

$$E_D > E_C > E_B > E_A$$

and from eq. (1)

$$\Rightarrow Q_D > Q_C > Q_B > Q_A$$

Hence, curve D represent $E - x$ curve of charge having bigger magnitude.

Therefore, option (d) is correct.

6. A cylinder of radius R and length L is placed in a uniform electric field E parallel to the cylinder axis. The total flux from the surface of the cylinder is

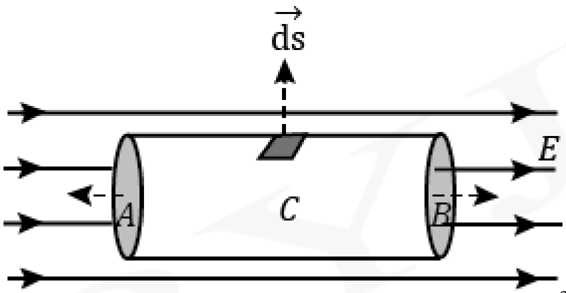
A. $2\pi R^2 E$

B. $\pi R^2 / E$

C. $(\pi R^2 - \pi R)/E$

D. Zero ✔

The electric flux passing through a surface of area A is $\varphi = \vec{E} \,.\, \vec{A}$



Flux through surface A is $\varphi_A = E \times \pi R^2$
and
Flux through surface B is $\varphi_B = -E \times \pi R^2$

Flux through curved surface C is
$\int \vec{E} \,.\, \vec{ds} = \int E ds \cos 90^\circ = 0$
$\therefore$ Total flux through cylinder $\varphi_A + \varphi_B + \varphi_C = 0$

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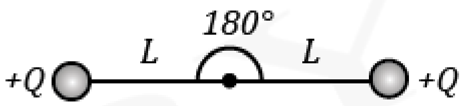
7. Two small spheres each having the charge $+Q$ are suspended by insulating threads of length L from a hook. This arrangement is taken in space where there is no gravitational effect. Then the angle between the two threads at the point of suspension and the tension in each thread will be

- ✔ **A.** $180^\circ, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{(2L)^2}$
- ✘ **B.** $90^\circ, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{L^2}$
- ✘ **C.** $180^\circ, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{2L^2}$
- ✘ **D.** $180^\circ, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{L^2}$

The position of the balls in the absence of gravitational force will become as shown below



Thus angle $\theta = 180^\circ$ and

force $F = \frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{(2L)^2}.$

8. If E is the electric field intensity of an electrostatic field, then the electrostatic energy density is proportional to

- ✗ **A.** E
- ✓ **B.** E^2
- ✗ **C.** $1/E^2$
- ✗ **D.** E^3

Electrostatic potential energy $U = \frac{CV^2}{2}$

As $C = \frac{\epsilon_0 A}{d}, V = Ed$

$\Rightarrow U = \frac{\epsilon_0 E^2}{2}(Ad)$

$\Rightarrow \frac{U}{(Ad)} = \frac{\epsilon_0 E^2}{2}$

Electrostatic energy per unit volume $\frac{1}{2}\epsilon_0 E^2$

Electrostatic energy density is $\propto E^2$

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9. Two point charges Q_1 and Q_2 placed at separation d in vacuum and force acting between them is F. Now a dielectric slab of thickness $\frac{d}{2}$ and dielectric constant $K = 4$ is placed between them. The new force between the charges will be

- ✔ A. $\frac{4F}{9}$
- ✖ B. $\frac{2F}{9}$
- ✖ C. $\frac{F}{9}$
- ✖ D. $\frac{5F}{9}$

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From the coulomb's law , the electrostatic force acting between two charges are inversly proportional to the square of the distance between them,

$$F \propto \frac{1}{d^2} \qquad \ldots\ldots(1)$$

When a dielectric slab of dielectric constant K is placed between the charges the distance $\frac{d}{2}$ in a medium is equivalent to a distance $\frac{d}{2}\sqrt{K}$ of vacuum. Now force acting between the charges, will be

$$F' \propto \frac{1}{\left(\frac{d}{2}+\frac{d}{2}\sqrt{K}\right)^2} \qquad \ldots\ldots(2)$$

Now from equation (1) and (2), we get,

$$\frac{F'}{F} = \frac{1}{\left(\frac{1}{2}+\frac{\sqrt{K}}{2}\right)^2}$$

Now substituting $K = 4$, we get,

$$\frac{F'}{F} = \frac{1}{\frac{1}{4}(1+\sqrt{4})^2}$$

$$\Rightarrow \frac{F'}{F} = \frac{F}{\left(\frac{9}{4}\right)}$$

$$\Rightarrow F' = \frac{4F}{9}$$

Hence, option (a) is the correct answer.

10. The electric potential decreases uniformly from $120 \mathrm{~V}$ to $80 \mathrm{~V}$ as one moves on the $x-$ axis from $x=-1 \mathrm{~cm}$ to $x=+1 \mathrm{~cm}$. The electric field at the origin.

✗ **A.** must be equal to $20 \mathrm{~V} / \mathrm{cm}$

✗ **B.** must be equal to $20 \mathrm{~V} / \mathrm{m}$

✓ **C.** may be greater than $20 \mathrm{~V} / \mathrm{cm}$

✗ **D.** may be less than $20 \mathrm{~V} / \mathrm{cm}$

Given,

Electric potential at $x_1=-1 \mathrm{~cm}$ is $V_1=120 \mathrm{~V}$

Electric potential at $x_2=+1 \mathrm{~cm}$ is $V_2=80 \mathrm{~V}$

Since the potential is uniformly decreasing, we can write that,

$$E_x=-\left(\frac{V_2-V_1}{x_2-x_1}\right)$$

$$\Rightarrow E_x=-\left(\frac{80-120}{1-(-1)}\right)=+20 \mathrm{~V} / \mathrm{cm}$$

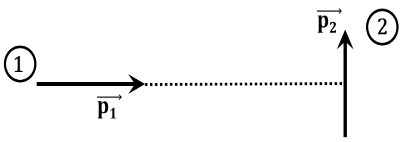
From the data given in the question, it is clear that, a positive charge recides somewhere having negative x , y and z coordinates.

Since, E_x is $x-$ component of electric field vector. The effect of $y-$ component and $z-$ component will also be at origin.

Thus, the electric field at origin may be greater than $+20 \mathrm{~V} / \mathrm{cm}$

Hence, option (c) is the correct answer.

11. Assertion(A): If a dipole $(\overrightarrow{p_1})$ is moved along the line normal to the axis (shown in dotted line) of another dipole $(\overrightarrow{p_2})$, their interaction energy does not change.

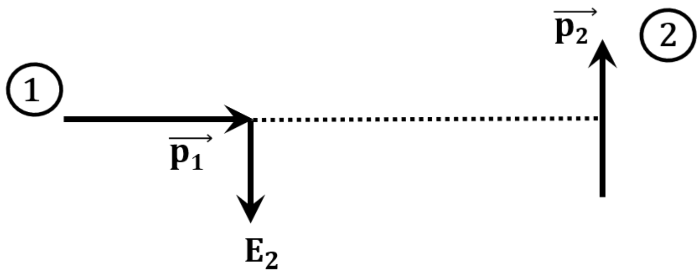


Reason(R): The electric field due to $(\overrightarrow{p_2})$ at the position of $(\overrightarrow{p_1})$ is normal to $(\overrightarrow{p_1})$

Select the most appropriate answer from the options given below

- ✔ **A.** Both A and R are true and R is the correct explanation of A
- ✖ **B.** Both A and R are true but R is not the correct explanation of A
- ✖ **C.** A is true but R is false
- ✖ **D.** A is false and R is also false

Field due to $(\overrightarrow{p_2})$ on $(\overrightarrow{p_1})$ is,



$\therefore (\overrightarrow{p_1}) \perp E_2$,
As we know, potential energy of a dipole is,

$$U = -\overrightarrow{p} \cdot \overrightarrow{E} = pE\cos\theta$$

Here, $\theta = 90^\circ \quad \Rightarrow \quad U = 0$

As the dipole$(\overrightarrow{p_1})$ moves along the dotted line, direction of Field due to $(\overrightarrow{p_2})$ on $(\overrightarrow{p_1})$ remains perpendicular to $(\overrightarrow{p_1})$
Hence interaction energy remains same.

Hence, (A) is the correct answer.

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12. Assertion(A): In the frame of reference where all the considered charges are at rest, the force experienced by a moving test charge due to all considered charges is purely electrical in nature.

Reason(R): A stationary charge produces an electric field only.

Select the most appropriate answer from the options given below

- ✔ **A.** Both A and R are true and R is the correct explanation of A
- ✖ **B.** Both A and R are true but R is not the correct explanation of A
- ✖ **C.** A is true but R is false
- ✖ **D.** A is false and R is also false

Moving charges can produce both electric and magnetic fields, while a stationary charge produces only an electric field on its surrounding region.

In the given frame of reference, where all the charges are at rest, only electric field would be present and hence the moving test charge will experience electrostatic force (which is purely electrical).

Hence, (A) is the correct answer.

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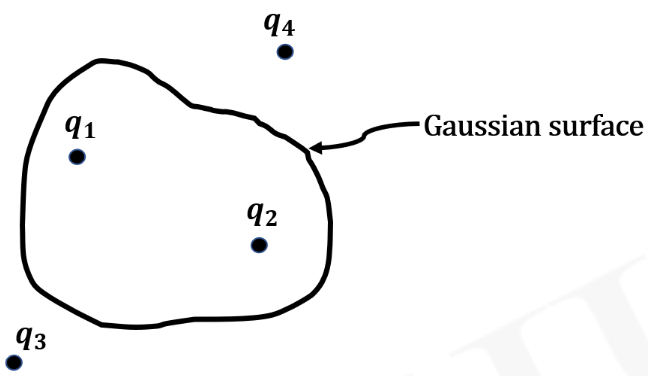
13. Assertion(A): Four point charges q_1, q_2, q_3 and q_4 are as shown in figure. The flux over the shown gaussian surface depends only on charges q_1 and q_2

Reason(R): Electric field at all points on gaussian surface is depends only on charges q_1 and q_2



Select the most appropriate answer from the options given below

- ✗ **A.** Both A and R are true and R is the correct explanation of A
- ✗ **B.** Both A and R are true but R is not the correct explanation of A
- ✓ **C.** A is true but R is false
- ✗ **D.** A is false and R is also false

According to Gauss's theorem,

For any closed surface, the net flux of the electric field passing through that surface is proportional to the total charge enclosed in it.

Therefore, assertion is true.

Electric field at any point on the gaussian surface is depends on all the charges in the vicinity of the gaussian suface. Thus, reason is false.

Hence, (C) is the correct answer.

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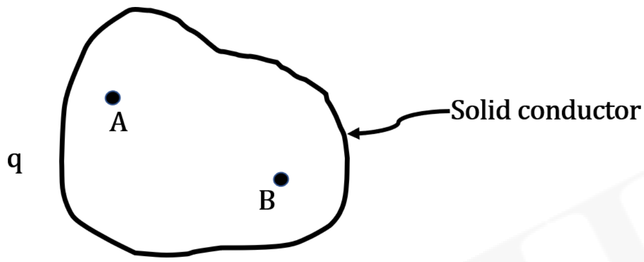
14. Assertion(A) : A point charge q is placed near an arbitrary shaped solid conductor, as shown in the figure. The potential difference between points A and B within the conductor remains same irrespective of the magnitude of the charge q.

Reason(R) : Electric field inside the solid conductor is zero under the electrostatic conditions.



Select the most appropriate answer from the options given below

- ✔ **A.** Both A and R are true and R is the correct explanation of A
- ✖ **B.** Both A and R are true but R is not the correct explanation of A
- ✖ **C.** A is true but R is false
- ✖ **D.** A is false and R is also false

Under electrostatic condition, Electric field inside the solid conductor is zero.

As we know, $E=-\dfrac{\Delta V}{\Delta x}$

If $E=0 \quad \Rightarrow \; V=\text{constant}$

Hence, point A and B will have same potential i.e., $V_A-V_B=0$

Hence, (A) is the correct answer.

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15. Assertion(A): In a region where, uniform electric field exists, the net charge within a volume of any size is zero.

Reason(R): Net electric flux within any closed surface in the region of uniform electric field is zero.

Select the most appropriate answer from the options given below

- ✔ **A.** Both A and R are true and R is the correct explanation of A
- ✘ **B.** Both A and R are true but R is not the correct explanation of A
- ✘ **C.** A is true but R is false
- ✘ **D.** A is false and R is also false

Net electric flux linked with any closed surface placed in the region of uniform electric field is zero. i.e., Number of electric lines of force entering the closed surface is equal to that of number of electric lines of force leaving the surface.

From Gauss's theorem, net flux through any closed surface will be zero, when no net charge is enclosed by the surface.

Hence, (A) is the correct answer.

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16. In a certain region, uniform electric field exists as $\overrightarrow{E} = E_0\hat{j}$. A proton and an electron are projected from origin at time $t = 0$ with certain velocities along $+x$-axis direction. Due to the electric field, they experience force and move in the xy-plane along different trajectories.

(i) The path followed by the particles will be a

- ✔ **A.** parabola
- ✘ **B.** circular
- ✘ **C.** hyperbola
- ✘ **D.** spiral

Since the acceleration provided by the electric field is perpendicular to the initial velocity of the particles, the path followed will be a parabola.

Hence, (A) is the correct answer.

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17. In a certain region, uniform electric field exists as $\vec{E} = E_0\hat{j}$. A proton and an electron are projected from origin at time $t = 0$ with certain velocities along $+x$-axis direction. Due to the electric field, they experience force and move in the xy-plane along different trajectories.

(ii) If they have same kinetic energy then for the same displacement along $+x$-direction, the deflection is

- ✗ **A.** more for proton
- ✗ **B.** more for electron
- ✓ **C.** equal for both
- ✗ **D.** independent of kinetic energy

As electric field exists along the y-axis,

$a_x = 0$ and $a_y = \dfrac{qE}{m}$

Let initial velocity along the x-axis be $u_x = v_0$

Displacement along the x-axis is,

$x = v_0 t \quad \Rightarrow \quad t = \dfrac{x}{v_0}$

Displacement along the y-axis is,

$$y = \frac{1}{2}at^2 = \frac{qEt^2}{2m}$$

$$\Rightarrow \quad y = \frac{qEx^2}{2m(v_0)^2} \qquad [\because \; K.E = \frac{1}{2}m(v_0)^2 \quad \Rightarrow \quad 2K.E = m(v_0)^2]$$

$$\Rightarrow \quad y = \frac{qEx^2}{2(2K.E)}$$

Hence, for same value of x and initial kinetic energy, y is same for the both.

Hence, (C) is the correct answer.

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18. In a certain region, uniform electric field exists as $\vec{E} = E_0\hat{j}$. A proton and an electron are projected from origin at time $t = 0$ with certain velocities along $+x$-axis direction. Due to the electric field, they experience force and move in the xy-plane along different trajectories.

(iii) If they have the same initial velocity then for the same displacement along x axis, displacement along y axis is

- ✗ **A.** more for proton
- ✓ **B.** more for electron
- ✗ **C.** equal for both
- ✗ **D.** independent of kinetic energy

As, electric field exist along the y-axis,

$a_x = 0$ and $a_y = \dfrac{qE}{m}$

Let initial velocity along the x-axis be $u_x = v_0$

Displacement along the x-axis is,

$x = v_0 t \quad \Rightarrow \quad t = \dfrac{x}{v_0}$

Displacement along the y-axis is,

$$y = \frac{1}{2}at^2 = \frac{qEt^2}{2m}$$

$$\Rightarrow \quad y = \frac{qEx^2}{2m(v_0)^2}$$

$$\Rightarrow \quad y \propto \frac{1}{m}$$

$\because$ mass of the proton (m_p)>mass of the proton(m_e)

Hence, the deflection of the electron is greater than the deflection of the proton.

Hence, (B) is the correct answer.

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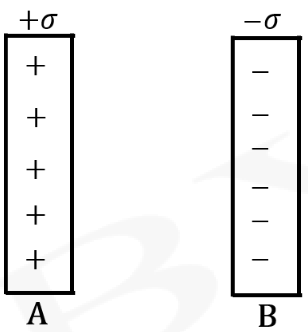
19. Charge between parallel plates :

Surface charge density is defined as the charge per unit surface area of surface charge distribution. i.e., $\sigma = \frac{q}{S}$

Two large thin metal plates are parallel and close to each other, on their inner faces, the plates have surface charge densities of opposite sign having magnitude of $1.70 \times 10^{-22}\ \mathrm{Cm^{-2}}$ as shown in figure.
[Use $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{Fm^{-1}}$]

(i) The electric field E in the region in between the plates A and B is



A. $12 \times 10^{-12}\ \mathrm{NC^{-1}}$

B. $2 \times 10^{-10}\ \mathrm{NC^{-1}}$

C. $0.2 \times 10^{-10}\ \mathrm{NC^{-1}}$ ✔

D. $1.2 \times 10^{-12}\ \mathrm{NC^{-1}}$

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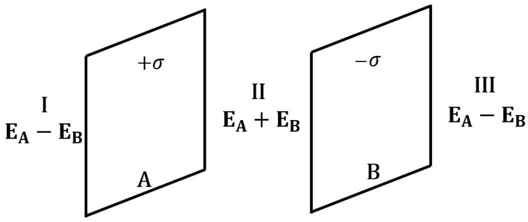

Given, surface charge densities of plate A and B is,

$\sigma_A = +1.70 \times 10^{-22}\ \mathrm{Cm}^{-2}\ ;\ \sigma_B = -1.70 \times 10^{-22}\ \mathrm{Cm}^{-2}$

Using gauss's law, electric field in the region between the plate A and B is,

$$E = E_A + E_B = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

$$\Rightarrow \quad E = \frac{\sigma}{\varepsilon_0} = \frac{1.70 \times 10^{-22}}{8.85 \times 10^{-12}}$$

$$\Rightarrow \quad E \approx 0.2 \times 10^{-10}\ \mathrm{NC}^{-1}$$

Hence, (C) is the correct answer.

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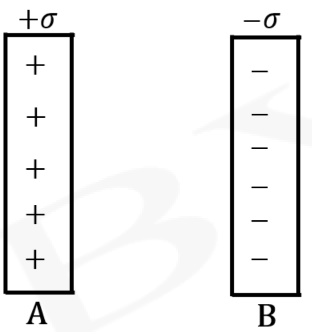
20. Charge between parallel plates :

Surface charge density is defined as the charge per unit surface area of surface charge distribution. i.e., $\sigma = \dfrac{q}{S}$

Two large thin metal plates are parallel and close to each other, on their inner faces, the plates have surface charge densities of opposite sign having magnitude of $1.70 \times 10^{-22}\ \mathrm{Cm^{-2}}$ as shown in figure.
[Use $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{Fm^{-1}}$]

(ii)The electric field E in the region to the left of plate A and to the right of plate B is



A. $1.2 \times 10^{-10}\ \mathrm{NC^{-1}}\ ;\ 1.2 \times 10^{-10}\ \mathrm{NC^{-1}}$

B. $1.2 \times 10^{-12}\ \mathrm{NC^{-1}}\ ;\ 1.2 \times 10^{-12}\ \mathrm{NC^{-1}}$

C. $0.2 \times 10^{-10}\ \mathrm{NC^{-1}}\ ;\ 0.2 \times 10^{-10}\ \mathrm{NC^{-1}}$

D. $0\ \mathrm{NC^{-1}}\ ;\ 0\ \mathrm{NC^{-1}}$ ✔

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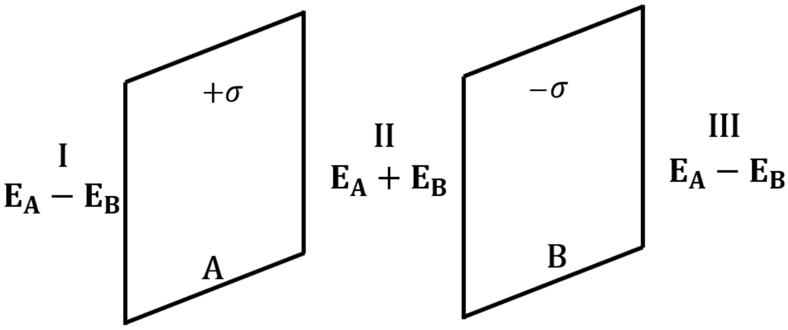

Given, surface charge densities of plate A and B is,

$\sigma_A = +1.70 \times 10^{-22}\ \mathrm{Cm}^{-2}$; $\sigma_B = -1.70 \times 10^{-22}\ \mathrm{Cm}^{-2}$

Using gauss's law, electric field outside the region of plate A is,

$$E = E_A - E_B = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

Similarly, electric field outside the region of plate B is,

$$E = E_A - E_B = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

Hence, (D) is the correct answer.