PH - 222A - 2A
IN-CLASS PRACTICE

NAME :- SHREYAS SRINIVASA

BLAZER ID :- SSRINIVA

1. Ans. $\vec{F} = q\vec{E}$

$\vec{F} = m\vec{a}$

(a) Force on proton can be calculated by :-

$$\vec{F} = q\vec{E}$$

Substituting $1.602 \times 10^{-19}\,C$ for q and $200\,\hat{i}\,N/C$ for $\vec{E}$,

$$\vec{F} = 1.602 \times 10^{-19}\,C \times 200\,\hat{i}\,N/C$$
$$= 3.204 \times 10^{-17}\,\hat{i}\,N$$

$$\vec{a} = \frac{\vec{F}}{m}$$

Substituting $3.204 \times 10^{-17}\,\hat{i}\,N$ for $\vec{F}$ and 1.67×10^{-27} kg for m

$$\vec{a} = \frac{3.204 \times 10^{-17}\, \hat{i}\, N}{1.67 \times 10^{-27}\, kg}$$

$$= 1.916 \times 10^{10}\ m/s^2$$

$\therefore$ force on proton is $\vec{F} = 3.204 \times 10^{-17}\, \hat{i}\, N$

& acceleration of proton is $\vec{a} = 1.916 \times 10^{10}\, \hat{i}\, m/s^2$

(b) Force on electron can be calculated by :- $\vec{F} = q\vec{E}$

Substituting $-1.602 \times 10^{-19} C$ for q and $200\,\hat{i}\, N/C$ for $\vec{E}$.

$$\vec{F} = -1.602 \times 10^{-19} C \times 200\, \hat{i}\, N/C$$
$$= -3.204 \times 10^{-17}\, \hat{i}\, N$$

negative sign shows that the force is acting in opposite direc-tion of the electric field.

$$\vec{a} = \frac{\vec{F}}{m}$$

substituting $-3.204 \times 10^{-17}\,\hat{i}$ N for $\vec{F}$ and 9.12×10^{-31} kg for m.

$$\vec{a} = \frac{-3.204 \times 10^{-17}\,\hat{i}\ N}{9.12 \times 10^{-31}\ kg}$$

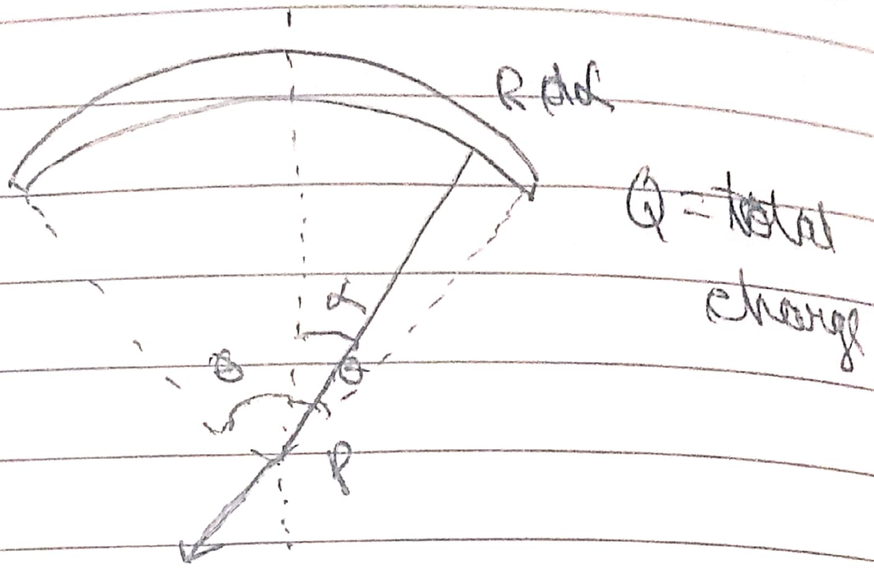
$$= -3.51 \times 10^{13}\,\hat{i}\ m/s^2$$

Negative sign shows that the direction of acceleration of electron is in opposite direction of the electric field.

$\therefore$ Force on electron is $\vec{F} = -3.204 \times 10^{-17}\,\hat{i}$ N

& acceleration of electron is
$\vec{a} = -3.51 \times 10^{13}\,\hat{i}\ m/s^2$

2. Ans:



To find:- Electric field at P.

Charge density $\lambda = \frac{Q}{R.(2\theta)} = \frac{Q}{2R\theta}$

$d\vec{E}$ due to element $R\,d\alpha$

$$d\vec{E} = \frac{K(dq)}{R^2} = \frac{K(\lambda)(R\,d\alpha)}{R^2}$$

$$= \frac{K\lambda(d\alpha)}{R}$$

Due to symmetry, horizontal components get cancelled.

$$d\vec{E}_y = \frac{k\lambda\,(d\alpha)}{R}\cdot\cos\alpha$$

$$\therefore E_{net} = \int_{-\theta}^{+\theta} \frac{k\lambda}{R}\cos\alpha\, .\, d\alpha$$

$$= -\frac{k\lambda}{R}\,(2\sin\theta)$$

$$= -\frac{k\lambda}{R}\,.\,2\sin\theta$$

$$= -\frac{k}{R}\,.\,\frac{Q}{2R\theta}\,.\,2\sin\theta$$

$$\therefore E_{net} = -\frac{KQ}{R^2}\,.\,\frac{\sin\theta}{\theta}$$

along the vertically downward direction.

3. Ans.: Electric flux, $\Phi = \int_s \vec{E} \cdot d\vec{A}$

$$= \frac{q_{encl}}{\epsilon_0}$$

(a) For point lies inside ($r < a$) the inner shell :-

The charge resides on the surface of the conductor. Meaning, there is no charge inside the conductor. Lets consider the shell as a conductor so, the charge resides on the surface of the shell. The electric field is directly proportional to the charge ∴ The electric field inside the shell is zero.

(b) The point lies inside the outer shell and outside the inner shell ($a < r < b$):

The expression for the surface area of the

Spherical shell is :- $A = 4\pi r^2$

Here, r is the radius of the spherical shell.

The charge enclosed by the gaussian surface is, $q_{enc} = +Q$

The electric flux through the gaussian surface is, $\phi = EA$

Substituting $4\pi r^2$ for A and $+Q$ for q_{enc}

$\therefore \phi = E(4\pi r^2)$

Substituting $\frac{q_{enc}}{\varepsilon_0}$ for ϕ.

$$\frac{q_{enc}}{\varepsilon_0} = E(4\pi r^2)$$

$$q_{enc} = E(4\pi \varepsilon_0 r^2)$$

8

Substituting Q for q_{enc} :-

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

$\therefore$ The electric field when $a < r < b$ is $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$.

(c) The point lies inside the material of the outer shell ($b < r < c$) $\therefore$

The negative charge resides on the surface of the spherical shell. Meaning that there is no charge enclosed by the gaussian surface.

The positive charge ($+Q$) on the inner shell, induces an equal and opposite charge $(-Q)$ on the inner surface of the outer spherical shell. Thus, the total charge enclosed by the Gaussian surface for the region $b < r < c$ is,

$$q_{enc} = +Q + (-Q)$$
$$= 0.$$

The electric field is directly proportional to the charge. Since the total charge enclosed by the Gaussian surface for the region $b < r < c$ is zero, the electric field for the region $b < r < c$ is also zero.

$\therefore$ The electric field for the region $b < r < c$ is zero.

(d) The point lies outside the inner shell as well as the outer shell $(r > c)$
$\therefore$ The negative charge resides on the surface of the spherical shell.

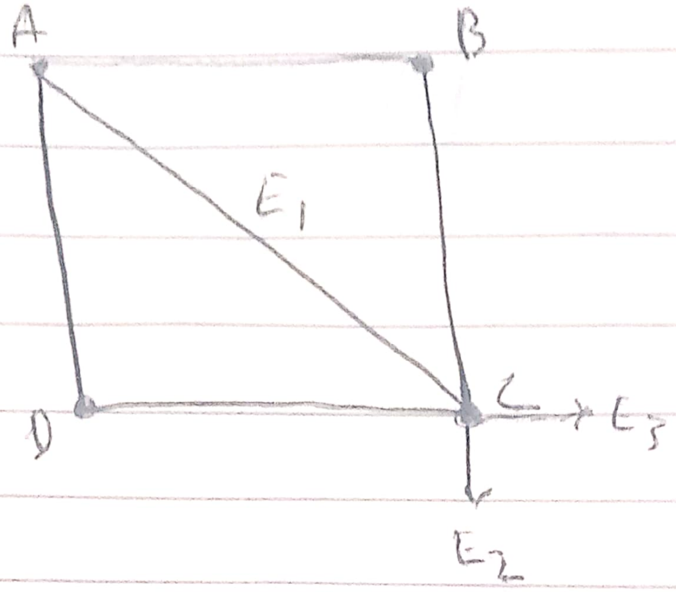
meaning that there is no charge enclosed by the gaussian surface. The positive charge $(+q)$ on the inner shell induces an equal and opposite charge $(-q)$ on the inner surface of the outer spherical shell. Thus the total charge enclosed by the gaussian surface for the region $r > R$ is;-

$$q_{enc} = +q - q$$
$$= 0$$

The electric field is directly proportional to charge. Since the total charge enclosed by the gaussian surface for the region $r > R$ is zero, the electric field for the region $r > R$ is also zero.

$\therefore$ The electric field for the region $r > R$ is zero.

4. Ans.



Electric field at C due to charge at A $(-2q_1)$.

$$\vec{E_1} = \frac{2q}{4\pi\varepsilon_0(a\sqrt{2})^2}\ \vec{CA}$$

$$= \frac{2q}{8\pi\varepsilon_0 a^2}\ \vec{CA}$$

Electric field at C due to charge at B q

$$\vec{E_2} = \frac{q}{4\pi\varepsilon_0 a^2}\ \hat{E_2}$$

and $$\vec{E_3} = \frac{q}{4\pi\varepsilon_0 a^2}\ \hat{E_3}$$

P.T.O

(12)

The net field at C is :-

$$\vec{E} = \left(\frac{2q}{8\pi\varepsilon_0 a^2} - \sqrt{2}\,\frac{q}{4\pi\varepsilon_0 a^2} \right) \vec{CA}$$

$$= \frac{q}{4\pi\varepsilon_0 a^2} \left[1 - \sqrt{2} \right) \vec{CA}$$

$$\vec{E} = \frac{q}{4\pi\varepsilon_0 a^2} (\sqrt{2} - 1)\, \vec{AC}$$

(b) force $F = \frac{q^2}{4\pi\varepsilon_0 a^2} (\sqrt{2}-1)$ along $\vec{AC}$