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class :- CSE / 1^{st} Semester
subject :- Physics / Mid-Term exam.
Roll no. :- 273
Sections :- C
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Q1) a) What are the magnitude ...... of (i) an electron & and (ii) A protorn?

(i) An electron :-

Electric force on a charged partical of charge "Q" placed in electric field of magnitude "E" is given by :-

"$F = EQ$"

Also, this electric force balances the weight of electron. So, it is given by;

$$mg = EQ$$

However, "m" is mass of electron and "g" is acceleration due to gravity.

Now, Solve for E, we get;

$$E = \frac{mg}{Q} \quad \text{———} \quad (1)$$

putting values in (1)

$$m = 9.109 \times 10^{-31} \text{ kg}$$

$$g = 9.80 \text{ m/s}^2$$

$$Q = -1.602 \times 10^{-19} \text{ C}$$

$$E = \frac{(9.109\times10^{-31}kg)(9.80m/s^2)}{-1.602\times10^{-19}C}$$

$$\boxed{E = 5.58\times10^{-11}N/C}$$

As the weight of the object ~~is~~ directed downward, the direction of electric force must be upward. As, direction of electric force on negatively charged partical is oppsite to the direction of electric field, so, the direction of electric field is downward.

Hence magnitude of electric field on electron is $\boxed{5.58\times10^{-11}N/C}$ and direction is downward.

ii) A protorn:-

For protorn we know that;

$$F_W = m_p g \quad -(1)$$

here;

m_p = mass of protron,

g = acceleration due to gravity

values are;

$$m_p = 1.67\times10^{-27}kg$$
$$g = 9.80m/s^2$$

~~putting values in (1)~~

The electric ~~field~~ force acting on protorn will be

$$F_e = eE \quad -(2)$$

So,

$$eE = m_p g$$

$$E = \frac{m_p g}{e}$$

putting values we get:

$$\boxed{E = 1.0 \times 10^{-7}\ N/C}$$

Hence magnitude is $\boxed{1.0 \times 10^{-7}\ N/C}$ and direction is upward.

Q1 (b) The electrons in a partical ...... distance d?

Ans) The work done on the charge is

$$W = \vec{F} \cdot \vec{d}$$

$$= q\vec{E} \cdot \vec{d}$$

And the kinetic energy changes according to,

$$W = K_f - K_i = 0 - K$$

Assuming $\vec{V}$ is in the $+x$ direction, we have,

$$(-e)\vec{E} \cdot d\hat{i} = -K$$

Then,

$$e\vec{E} \cdot (d\hat{i}) = K \text{ and}$$

$$\vec{E} = \frac{K}{ed}\hat{i}$$

So,

$$\boxed{E = \frac{K}{ed}}$$

(P.T.O).

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Direction is in direction of motion because a negative charge experiences an electric force opposite to the direction of an electric field.

Q2) b) consider a ...... where $r<R$.

Ans:- using gaus's law, we get;

$$\Phi_E = \oint \vec{E} \cdot dA = \frac{q_{in}}{\varepsilon_0}$$

$$\oint E dA = \frac{q_{in}}{\varepsilon_0}$$

$$E \oint dA = \frac{q_{in}}{\varepsilon_0}$$

$$EA = \frac{q_{in}}{\varepsilon_0} \quad -(1)$$

where,

$$A = 2\pi r l$$

$$q_{in} = \rho V$$

putting in (1)

$$E(2\pi r l) = \frac{\rho V}{\varepsilon_0}$$

The volume of cylinder is

$$V = \pi r^2 l$$

$$E(2\cancel{\pi}\cancel{r}\cancel{l}) = \frac{\rho(\cancel{\pi} r^2 \cancel{l})}{\varepsilon_0}$$

$$\boxed{E = \frac{\rho r}{2\varepsilon_0}}$$ Ans.

Q3)A) Nobel .... assertion.

Ans: Suppose each person has mass 70 kg. In terms of elementary charges, each person consists of precisely equal number of protrons and electrons and as needly equal number of neutrons. The electrons comprise very little of the mass, so for each person we find the total number of protorns and neutrons, taken together:

$$(70\,kg)\left(\frac{1\,u}{1.66\times10^{-27}\,kg}\right) = 4\times10^{28}\,u$$

of these, nearly on half, 2×10^{28}, are protorns and 1% of this is 2×10^{26}, constituting a charge of $(2\times10^{26})(1.6\times10^{-19}c) = 3\times10^{7}C$

Thus, Feyman's force has magnitude

$$F = k_e\frac{q_1 q_2}{r^2}$$

Putting values.

$$F = \frac{(8.99\times10^{9}\,Nm^2/c^2)(3\times10^{7}c)^2}{(0.5\,m)^2} \sim 10^{26}\,N$$

where we have used a half meter arm's length. According to the particle in a gravitational field model, if the earth were in an externally produced uniform gravitational field of magnitude $9.80\,m/s^2$, it would weigh

$$F_g = mg$$

$$F_g = (6\times10^{24}\,kg)(10\,m/s^2)$$

$$\sim 10^{26}\,N$$

Thus the forces are the order of magnitude

Q3) A) An infinitely long .... everywhere.

Ans:- By symmetry, the electric field everywhere is prependicular to the surface of the cylindrical shell and point from the center line of charge to the outside. So, we break this down into three cases, and build the gaussian surface to be a cylindrical face with it's curved surface parallel to the cylindrical shell, radius r, and length L.

Case 1 :- $0<r<a$

In this case, the charge enclosed would be just due to the line of charge. Therefore applying Gauss's law, we have

$$E(2\pi r l) = 4\pi K_e(\lambda l)$$

~~whig~~ which gives

$$E = \frac{2k_e\lambda}{r}$$

Case 2 :- $a<r<b$

(P.T.O)

charge enclosed would include the one ~~force~~ from the Line of charge and the proportion of the charge from the cylindrical shell. The Volume of the charge from the cylindrical shell that would be enclosed by Gaussian surface is

$$V = \pi r^2 L - \pi a^2 L = \pi L (r^2 - a^2)$$

Therefore, apply Gauss's law

$$E(2\pi r L) = 4\pi k_e (\lambda L + \overset{\text{rho}}{\underline{\rho}} \pi L (r^2 - a^2))$$

which gives

$$E = 2k_e \frac{(\lambda + \overset{\text{rho}}{\underline{\rho}} (r^2 - a^2))}{r}$$

• CASE $\underline{III}$:- $r > b$

Similar to case 2, we have

$$E(2\pi r L) = 4\pi k_e (\lambda L + \overset{\text{Rho}}{\underline{\rho}} \pi L (b^2 - a^2))$$

~~which~~ :

which gives

$$E = 2k_e \frac{(\lambda + \rho \pi (b^2 - a^2))}{r}$$

In conclusion.

$$E = \begin{cases} \frac{2k_e \lambda}{r} , & 0<r<a \\ 2k_e(\lambda+\rho\pi(r^2-a^2)) , & a<r<b \\ \frac{2k_e(\lambda+\rho\pi(b^2-a^2))}{r} , & r>b \end{cases}$$

Q3) b) calculate .... charge Q.

Soln

we know that work done on a charge Q is:

$$dW = Q\,dV$$

Potential of a sphere of dQ charge having radius R is

$$dV = k_e\left(\frac{dQ}{R}\right)$$

when we integrate dQ from 0 to Q we get;

$$W = \frac{K_e \times Q^2}{2R}$$

So, the work must be done to charge a spherical shell of radius R to a total charge Q is given by

$$\boxed{W = \frac{K_e Q}{2R}}$$

Q4) A) A partical ...... having radius $r = 2R/3$.

Ans:- The equipotential surface is a sphere centered at

$\left(-\frac{4}{3}R, 0, 0\right)$

The radius is $\sqrt{a^2} = \sqrt{\frac{4}{9}R^2}$

$$a = \sqrt{\frac{4}{9}}\sqrt{R^2}$$

$$a = \sqrt{\left(\frac{2}{3}\right)^2} R$$

$$\boxed{a = \frac{2}{3}R}$$

Q4) b) show that ...... $U = kQ^2/2R$

Ans:- Energy stored in a conducting sphere will be in the form of electric potential Energy and will be equal to net working as

$$\int w = \int u$$

$$\int \partial u = \int F \cdot R$$

$$\int \partial u = \int \frac{kQ\,\partial q}{R^{\cancel{2}}} \cdot \cancel{R}$$

$$\int \partial u = \int \frac{kQ\,dq}{R}$$

$$\Rightarrow U = \frac{k}{R} \int_0^R Q\,dq$$

$$\Rightarrow U = \frac{k}{R} \left(\left(\frac{Q^2}{2} \right) \Big|_0^2 \right)$$

$$\Rightarrow \boxed{U = \frac{kQ^2}{2R}}$$