Physics
Theory Part 11

Topics: Nuclear Physics/ Electrostatics
Course: B.Sc/ Physics

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Q-21 The Half life of an Isotope of Phosphorus is 14 days. If a Sample Contain 3.0×10^{16} such nuclei. Determine its Activity(Ci).

Sol: Given $t_{1/2}=14$ days, $N=3\times10^{16}$, Activity, $R=\frac{0.693N}{t_{1/2}}$

$$\therefore R=\frac{0.693\times3\times10^{16}}{14\times24\times60\times60}=1.71\times10^{10}\ Bq \quad \text{Now } 1\ Bq = 1/3.7\times10^{10}\ Ci$$

$$\therefore R=\frac{1.71\times10^{10}}{3.7\times10^{10}}=\frac{171}{370}\ Ci=\boxed{0.462\ Ci}$$

Q-20 Calculate the difference in Binding Energy (BE)/nucleon for the isobars $^{23}_{11}Na$ (mass 22.989770 u) & $^{23}_{12}Mg$ (mass 22.994174 u)

Sol: If the Atom is $^{A}_{Z}X$ then $BE=[Zm_p+(A-Z)m_n-m(^{A}_{Z}X)]\,931.494$ MeV/u

where m_p = mass of Proton = 1.007825 u, m_n = mass of neutron = 1.008665 u

$\therefore$ for $^{23}_{11}Na$, $BE=[11m_p+12m_n-22.989770u]\,931.494$ MeV/u

$$=[11\times1.007825u+12\times1.008665u-22.989770u]\,931.49\ \text{MeV/u}$$

$$=186.565\ \text{MeV}$$

Now BE/Nucleon $=\frac{186.565}{23}=8.11$ MeV.

Similarly for $^{23}_{12}Mg$, $BE=[12m_p+11m_n-22.994174u]\,931.494$ MeV/u

$$=[12\times1.007825u+11\times1.008665u-22.994174u]\,931.494\ \text{MeV/u}$$

$$=181.6832\ \text{MeV/u}$$

Now BE/Nucleon $=\frac{181.6832}{23}=7.899$ MeV

Now Difference in BE/Nucleon $=(8.11-7.89)$ MeV $=\boxed{0.22\ MeV}$

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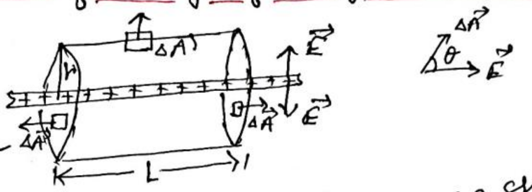
Electric Field due to Infinite Line of charge of charge density λ C/m.



(a) Gaussian surface - It is a cylindrical surface of length L & radius r, concentric with the wire.

Electric field is radially out from the line of charge as shown.

End faces of the cylinder do not contribute to the flux as its direction of the elemental area $\Delta \vec{A}$ is $\perp$ $\vec{E}$. Only the curved surface contribute ($\Delta\vec{A} \parallel \vec{E}$).

Since flux, $\phi = \int \vec{E}\cdot\Delta\vec{A} = |\vec{E}||\Delta\vec{A}|\cos\theta = 0$ when $\theta = 90°$.

(b) Only curved surface contribute to Electric field.

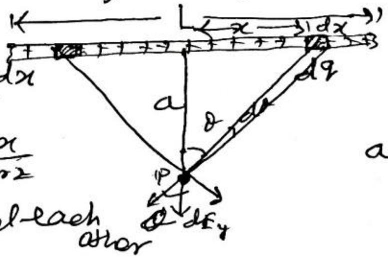
By Gauss's law, $\phi = \int \vec{E}\cdot d\vec{s} = \int \vec{E}\cdot\Delta\vec{A} = E \times \int \Delta A = 2\pi r L \times E$

$\therefore$ Total flux from the cylinder $= 2\pi r L \times E$ — (1)

Also $\phi = \dfrac{q}{\epsilon_0} = \dfrac{\int \lambda\, dl}{\epsilon_0} = \dfrac{\lambda L}{\epsilon_0}$ — (2) Comparing (1) & (2)

$2\pi r L \times E = \dfrac{\lambda L}{\epsilon_0} \Rightarrow \boxed{E = \dfrac{\lambda}{2\pi\epsilon_0 r}}$ so electric field is independent of length of the conductor.

In vector form $\vec{E} = \dfrac{\lambda}{2\pi\epsilon_0 r}\hat{r}$ (radially out of the conductor)



(c) E.F at P, $E = \dfrac{1}{4\pi\epsilon_0}\dfrac{dq}{r^2}$ due to length element dx, $dq = \lambda dx$

$= \dfrac{1}{4\pi\epsilon_0}\dfrac{\lambda d\theta}{a}$ $\quad \because \dfrac{d\theta}{a} = \dfrac{dx}{r^2}$ $\quad a = r$

$dE_y = \dfrac{1}{4\pi\epsilon_0}\dfrac{\lambda}{a}\cos\theta\, d\theta$, x-comp. will cancel each other

$E_y = \int_{-\theta}^{+\theta} \dfrac{\lambda}{4\pi\epsilon_0 a}\cos\theta\, d\theta = \boxed{\dfrac{\lambda}{4\pi\epsilon_0 a}\int_{-\theta}^{\theta}\cos\theta\, d\theta}$, for infinite line $\theta = \pi/2$

$E_y = \dfrac{\lambda}{4\pi\epsilon_0}\left[\cos\frac{\pi}{2} + \cos\frac{\pi}{2}\right] = \boxed{\dfrac{\lambda}{2\pi\epsilon_0 a}}$

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