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CHEMICAL ENGINEERING
PHYSICS 102

2a. Electric field is a region around a charge in which it exert electrostatic force in another charge while electric field intensity is the strength of electric field

2b. $Q_1 = 8nc$, $Q_2 = 12nc$

D net electric field at point P on the same axis at $x = 7$

$E = E_1 + E_2$

$E = \frac{kq_1}{r^2} + \frac{kq_2}{r^2}$

$E = \frac{9\times10^9 \times (8\times10^{-9})}{7^2} + \frac{90\times10^9 \times 12\times10^{-9}}{3^2}$

$= 1.47 + 12$

$= 13.47 \simeq 13.5 N/C$

$E_2 = \frac{kq_2}{r^2}$ $E_1 = \frac{kq_1}{r^2}$

$\frac{9\times10^{-9} \times 12\times10^{-9}}{5^2}$ $\frac{9\times10^9 \times 2\times10^{-9}}{3^2}$

$4\ 32 N/C$ $8.0 N/C$

Resultant field at Q in the x-direction

$E_2 = E_2 \sin\theta$

$\sin E = 0.8$

$= 4.32 \times 0.8$

$= 3.46 N/C$

$E_y = E_1 + E_2 \cos E$

$\cos\theta = 0.6$

$[8 + (4.32 \times 0.6)]$

$8 + 2.592 = 10.6\,N/C$.

5a Volume charge density (ρ) This is the quantity of charge per unit volume measured in the S.I system (C/m^3) at any point in a volume

Surface charge density (σ) This is the quantity of charge per unit area measured in coulombs per square meter (C/m^2) at any point on a surface distribution on a two dimensional surface

Linear charge density (λ) This is the quantity of charge per unit length, measured in coulombs per meter (C/m) at any point on a line charge distribution

b. Electric Potential: This is the electric potential energy per unit charge

$V = \frac{PE}{q}$ since PE is proportional to q, the dependence on q cancels

$\Delta V = V_B - V_A = \Delta PE/q$

c. $Q_1 = -10 \quad Q_2 = -2$.

Q_1 = left Q_2 = right and in between to the left ($x<0$)

$V = K \times 10 \; 2x = 10(4+x)$

$= -40/8 = -5m$

∴ in between

$V = K10/x - 2K \div (4-x)$

∴ to the right.

$10x - 40 = 2x$

$10x - 2x = 40$

$8x = 40$

$\therefore x = 5m$.

4a. Magnetic flux is defined as the strength of magnetic field represented by lines force

b. $m = 9.11 \times 10^{-31}kg$ $r = 1.4 \times 10^{-7}m$ $B = 3.5 \times 10e^{-1}$ $q = 1.6 \times 10e^{-19}$

cyclotron frequency $f = \frac{qB}{m}$

$$f = \frac{1.6 \times 10e^{-19} \times 3.5 \times 10e^{-1}}{9.11 \times 10e^{-31}}$$

$$= \frac{5.6 \times 10e^{-20}}{9.11 \times 10e^{-31}}$$

$$= 6.147 \times 10e^{10} \text{ rad/s}$$

5a. Biot-Savart law states the following observation for the magnetic fields $\vec{dB}$ at a point P associated with a length element $d\vec{l}$ of a wire carrying a steady current I.

b 

applying the Biot Savart law, we find the magnitude of the field $\vec{B}$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin\Phi}{r^2}$$

$$\sin(\pi - \Phi) = \sin\Theta$$

$$\therefore B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \varphi)}{r^2}$$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \varphi)}{x^2+y^2}$$

But $\sin(\pi - \varphi) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} dl \frac{x}{(x^2+y^2)^{1/2}(x^2+y^2)}$$

Recall $dl = dy$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}} dy$$

$$B = \frac{\mu_0 I x}{4\pi} \int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}}\, dy$$

$$\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \frac{y}{(x^2+y^2)^{1/2}}$$

$$\therefore B = \frac{\mu_0 I x}{4\pi} \left[\frac{y}{x^2 (x^2+y^2)^{1/2}} \right]_{-a}^{a}$$

$$B = \frac{\mu_0 I x}{4\pi} \left(\frac{2a}{x^2 (x^2+a^2)^{1/2}} \right]$$

$$B = \frac{\mu_0 I}{4\pi x} \left(\frac{2a}{(x^2+a^2)^{1/2}} \right]$$

$$(x^2+a^2)^{1/2} \simeq a, \text{ as } a \to \infty$$

$$\therefore B = \frac{\mu_0 I}{2\pi x}$$

$$\therefore B = \frac{\mu_0 I}{2\pi r}$$