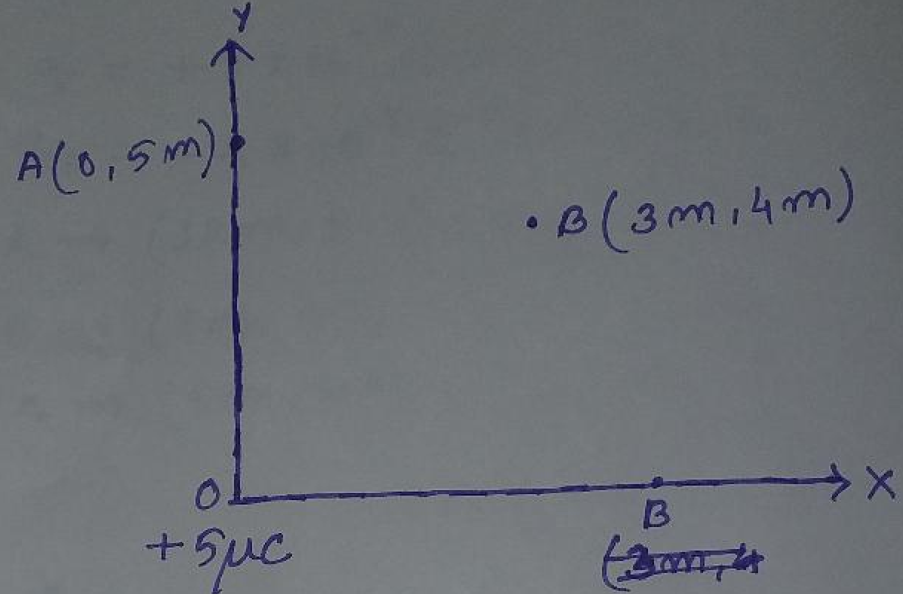
3. A point charge of $+5\mu C$ is placed at the origin of co-ordinate system. An electron is to be moved from (0, 5m) to ~~(3,4~~ (3m, 4m). Find the work done.

Ans :-




We know,

$$W_{A\to B} = q_0 (V_B - V_A)$$

given,

$q = +5\times10^{-6}$ C

$q_0 = -1.6\times10^{-19}$ C

$r_A = 5$ m

$r_B = 3$ m

Now, $V_A = 9\times10^9 \frac{q}{r_A} = 9\times10^9 \frac{+5\times10^{-6}}{5}$

$= 9\times10^3$ V

$V_B = 9 \times 10^9 \dfrac{q}{r_B} = 9 \times 10^9 \dfrac{3 \times 10^{-6}}{3}$

~~$= 15 \times 10^3$ V.~~ $= 9 \times 10^3$ V.

$W_{A \to B} = q_0 (V_B - V_A)$

$= -1.6 \times 10^{-19} (9 - 9) 10^3$

~~$= -9.6 \times 10^{-16}$ J~~ $= 0$

Q4. A point charge of $+8\,\mu C$ is placed at the origin of co-ordinate system. An electron another charge of $-2\,nC$ is to be moved from $(12m, 5m)$ to $(3m, 4m)$ via $(5m, 5m)$. Find the work done.

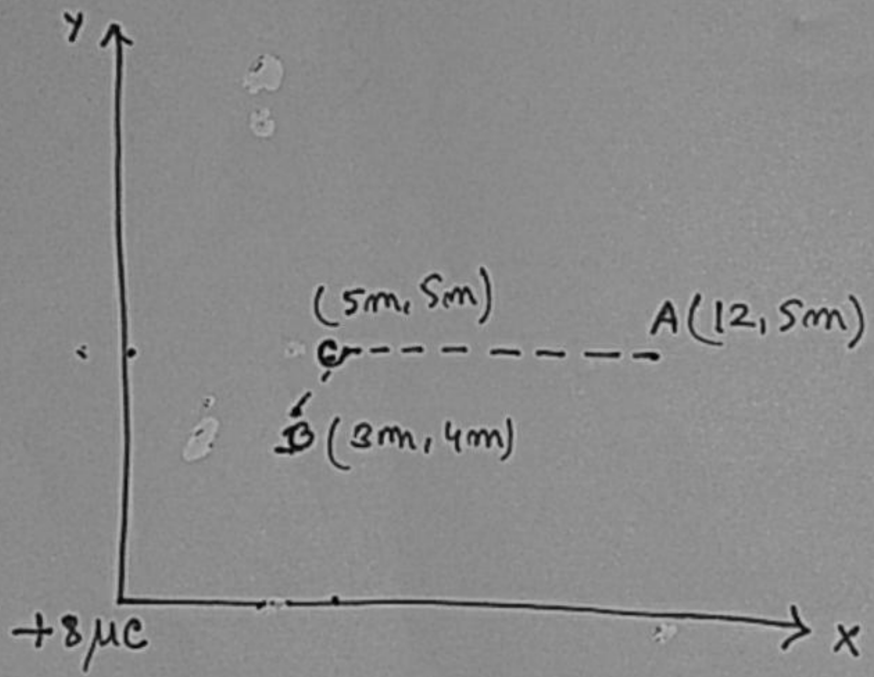
Soln :- Given, $q = +8 \times 10^{-6}\,C$

$q_0 = -2 \times 10^{-9}\,C$

$A \rightarrow (12m, 5m)$

$B \rightarrow (3m, 4m)$

$C \rightarrow (5m, 5m)$




∵ Workdone by conservative force depends on initial and final position and not on the path it travelled.

So $\Rightarrow W_{A \rightarrow C \rightarrow B}$

$= W_{A \rightarrow B}$

$$V_A = 9 \times 10^9 \frac{q}{r_A} = 9 \times 10^9 \frac{8 \times 10^{-6}}{13} = 5.5 \times 10^{3} \text{ V}$$

$$V_B = 9 \times 10^9 \frac{q}{r_B} = 9 \times 10^9 \frac{8 \times 10^{-6}}{5} = 14.4 \times 10^{3} \text{ V}$$

$$W_{A \to B} = q_0 (V_B - V_A)$$

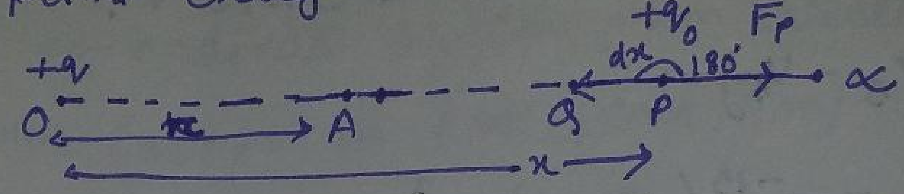
$$= -2 \times 10^{-9} (14.4 - 5.5) 10^{3}$$

$$= -17.8 \times 10^{-6} \text{ J}$$

~~5. Ans :-~~

5. Find an expression for the electric potential due to a point charge.

Ans :-




Let the point charge $+q$ be at O, due to which we have to find out electric potential at A, $OA = r$.

By defn, electric potential at A,

$$V_A = \frac{W_{\infty \to A}}{q_0} \longrightarrow (I)$$

[where $W_{\infty \to A}$ is the amount of workdone in moving $+q_0$ from infinity to A]

Let $OP = x$ [where $r < x < \infty$]

Let the test charge $+q_0$ at P

Repulsive force between $+q$ at O and $+q_0$ at P

$$F_P = \frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} \text{ [Towards right]} \longrightarrow (II)$$

Let $\vec{PQ} = \vec{dx}$

The small amount of workdone in bringing $+q_0$ from P to Q,

$$dW_{P \to Q} = \vec{F_P} \cdot \vec{PQ} = F_P\, dx \cos 180° \quad \left[\vec{F_P} \text{ and } \vec{PQ} \text{ are in opposite direction}\right]$$

$$= -\frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} dx \longrightarrow (III)$$

$$\therefore W_{\infty \to A} = \int dW_{P \to Q}$$

$$= \int_{\infty}^{r} -\frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} \, dx$$

$$= -\frac{1}{4\pi\epsilon_0} q q_0 \int_{\infty}^{r} \frac{dx}{x^2}$$

$$\Rightarrow \frac{W_{\infty \to A}}{q_0} = -\frac{1}{4\pi\epsilon_0} q \left[ -\frac{1}{x} \right]_{\infty}^{r}$$

$$\Rightarrow V_A = \frac{1}{4\pi\epsilon_0} q \left[ \frac{1}{r} - \frac{1}{\infty} \right]$$

$$\Rightarrow V_A = \frac{1}{4\pi\epsilon_0} \frac{q}{r} .$$