Q- Two charges are fixed in place with a separation d. One charge is positive and has seven times ( $n=7$ ) the magnitude of the other charge, which is negative. The positive charge lies to the left of the negative charge. Relative to the negative charge, locate the two spots on the line through the charges where the total potential is zero.

The potential due to a point charge q at a distance r from a point charge is given by

$$
V=\frac{1}{4 \pi \epsilon_{0}} \frac{q}{r}
$$

The potential is a scalar quantity and hence we have to consider only its magnitude not the direction.


Let at a point $P$ at distance $\times$ from the $-q$ charge to the right is zero then Potential at $P$ due to charge $-q$ will be

$$
V_{1}=\frac{1}{4 \pi \epsilon_{0}} \frac{(-q)}{x}=-\frac{1}{4 \pi \epsilon_{0}} \frac{q}{x}
$$

The distance of the point is $d+x$ from the positive charge and hence the potential at point $P$ due to the positive charge will be

$$
V_{2}=\frac{1}{4 \pi \in_{0}} \frac{7 q}{x+d}
$$

Hence the total potential at point P will be given by the sum to the two potentials and is

$$
V_{1}+V_{2}=\frac{1}{4 \pi \epsilon_{0}}\left(-\frac{q}{x}+\frac{7 q}{x+d}\right)=\frac{q}{4 \pi \epsilon_{0}}\left(-\frac{1}{x}+\frac{7}{x+d}\right)
$$

As this potential is to be zero at point $P$, we have

$$
\begin{aligned}
& \quad \frac{q}{4 \pi \epsilon_{0}}\left(-\frac{1}{x}+\frac{7}{x+d}\right)=0 \\
& \text { Or } \quad-\frac{1}{x}+\frac{7}{x+d}=0 \\
& \text { Gives }-\mathrm{x}-\mathrm{d}+7 \mathrm{x}=0 \\
& \text { Or } \quad \mathrm{x}=\mathrm{d} / 6
\end{aligned}
$$

Let the point $P$ at distance $x$ from the -q charge on the left side (-ve)
Potential at P due to charge -q will be

$$
V_{1}=\frac{1}{4 \pi \epsilon_{0}} \frac{(-q)}{x}=-\frac{1}{4 \pi \epsilon_{0}} \frac{q}{x}
$$

The distance of the point is $d+x$ from the positive charge and hence the potential at point $P$ due to the positive charge will be

$$
V_{2}=\frac{1}{4 \pi \epsilon_{0}} \frac{7 q}{d-x}
$$

Hence the total potential at point P will be given by the sum to the two potentials and is

$$
V_{1}+V_{2}=\frac{1}{4 \pi \epsilon_{0}}\left(-\frac{q}{x}+\frac{7 q}{d-x}\right)=\frac{q}{4 \pi \epsilon_{0}}\left(-\frac{1}{x}+\frac{7}{d-x}\right)
$$

As this potential is zero we have

$$
\frac{q}{4 \pi \epsilon_{0}}\left(-\frac{1}{x}+\frac{7}{d-x}\right)=0
$$

Or $\quad-\frac{1}{x}+\frac{7}{d-x}=0$
Gives - $d+x+7 x=0$
Or $\quad x=d / 8$
The point cannot be on the left of +7 q charge because in that case the positive potential will always greater to the negative potential and the sum cannot be zero.

