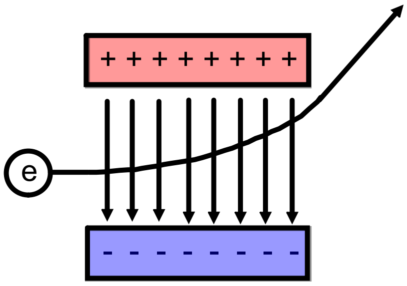
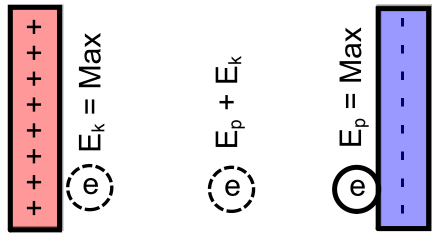
L09 - Parallel Plates and Conservation of Energy

Projectile Motion



1. $\vec{E}$
2. $\vec{F}$
3. $\vec{a}$
4. + 5. Kinematics

Conservation of Energy



Option #1

1. $\vec{E}$
2. $\vec{F}$
3. $\vec{a}$
4. $v_f^2 = v_i^2 + 2ad$

Require Δd

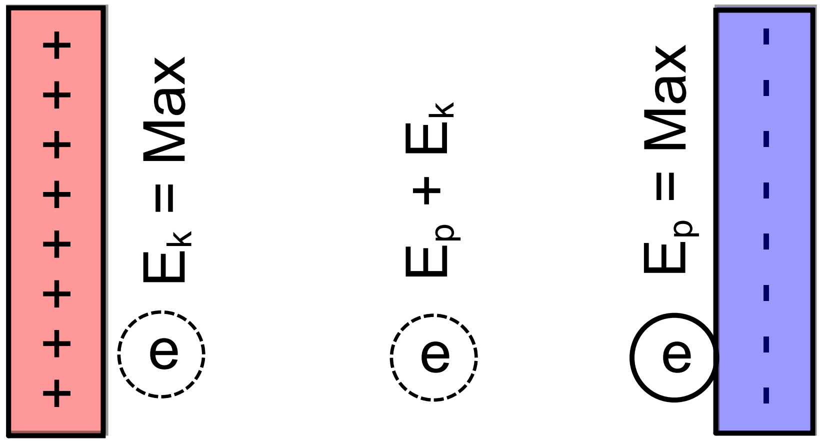
Option #2

$\Delta V = \frac{\Delta E_p}{q} \Rightarrow \boxed{\Delta E_p = q\Delta V}$

$E_p \rightarrow E_k$

$q\Delta V \rightarrow \frac{1}{2}mv^2$

Conservation of Energy - How it Works?



$$\vec{v}_{ave} = \frac{\Delta \vec{d}}{\Delta t}$$

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta V = \frac{\Delta E}{q}$$

$$|\vec{E}| = \frac{\Delta V}{\Delta d}$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$

Q1: Two oppositely charged parallel plates have a voltage of 2.5 x 10 ⁴ V between them. If 1.24J of work is required to move a small charge from one plate to the other, calculate the magnitude of the charge.

$$\vec{v}_{ave} = \frac{\Delta \vec{d}}{\Delta t}$$

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

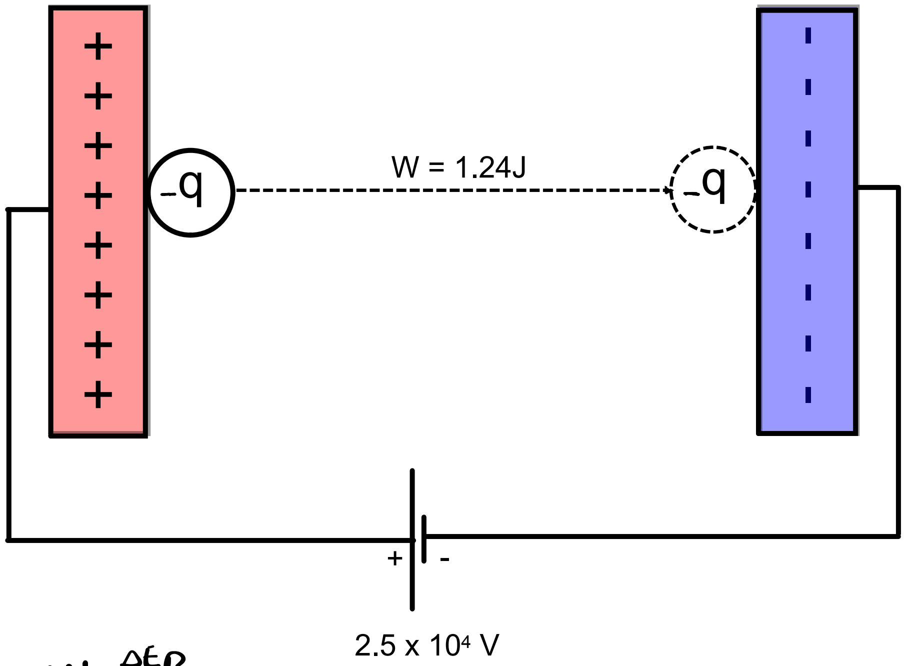
$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta V = \frac{\Delta E}{q}$$

$$|\vec{E}| = \frac{\Delta V}{\Delta d}$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$



$W = \Delta E$

$\Delta V = \frac{\Delta E_p}{q}$

$E_p = q\Delta V$

$1.24 = q(2.5 \times 10^4)$

$q = 4.96 \times 10^{-5}$ C Nope!

$\boxed{q = -4.96 \times 10^{-5} \text{ C}}$

Q2: Calculate the potential difference required to accelerate a deuteron with a mass of 3.3×10^{-27} kg and a charge of magnitude 1.6×10^{-19} C from rest to a speed of 8.0×10^{5} m/s.

$$\vec{v}_{ave} = \frac{\Delta \vec{d}}{\Delta t}$$

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

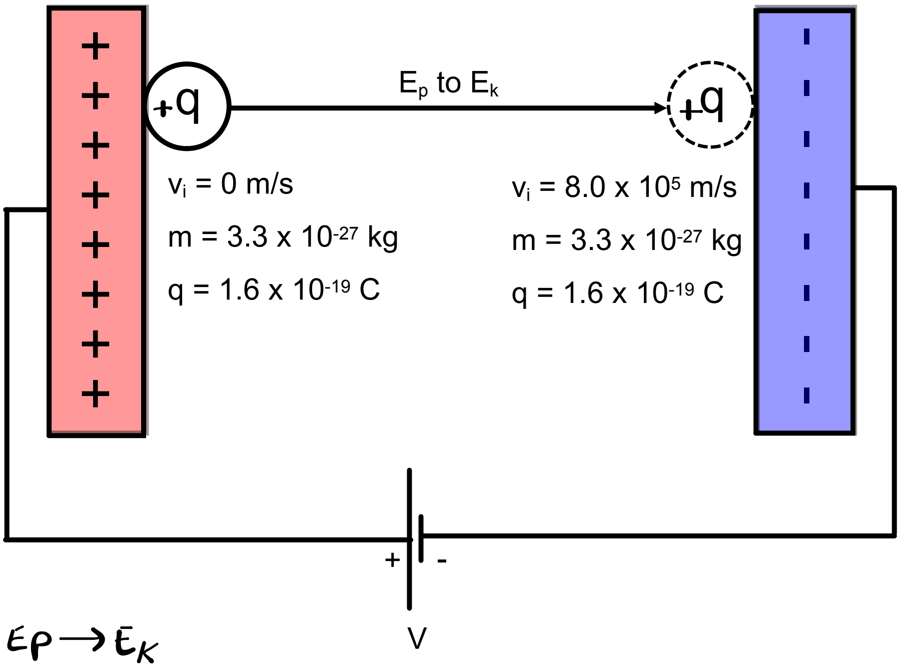
$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta V = \frac{\Delta E}{q}$$

$$|\vec{E}| = \frac{\Delta V}{\Delta d}$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$



$E_p = q\Delta V$

$E_p \rightarrow E_k$

$q\Delta V \rightarrow \frac{1}{2}mv^2$

$(1.6\times10^{-19})\Delta V = \frac{1}{2}(3.3\times10^{-27})(8.0\times10^{5})^2$

$\Delta V = 6600\ V$

$\approx 6.60\times10^{3}\ V$

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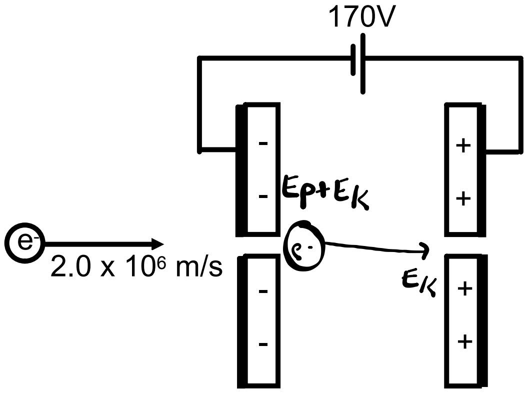
Q3: An electron travelling at 2.0 x 10 ^{6} m/s enters a parallel plate with a voltage difference of 170V. What is it's final speed as it exits the parallel plates?



$$E_i \longrightarrow E_f$$

$$E_{K_i} + E_{P_i} \longrightarrow E_{K_f}$$

$$\frac{1}{2}mv_i^2 + q\Delta V = \frac{1}{2}mv_f^2$$

$$\frac{1}{2}(9.11\times10^{-31})(2\times10^{6})^2 + (1.60\times10^{-19})(170) = \frac{1}{2}(9.11\times10^{-31})v_f^2$$

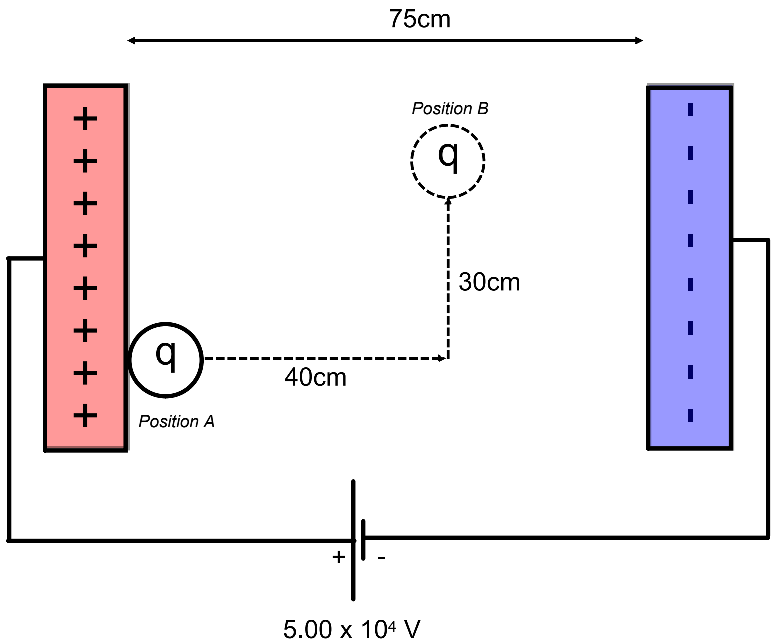
$$1.822\times10^{-18} + 2.72\times10^{-17} = \frac{1}{2}(9.11\times10^{-31})v_f^2$$

$$2.9022\times10^{-17} = \frac{1}{2}(9.11\times10^{-31})v_f^2$$

$$6.3714...\times10^{13} = v_f^2$$

$$\boxed{v_f = 7.98\times10^{6}\ m/s}$$

Q4: How much work, in Joules, is required to move a charge of -20e from *Position A* to *Position B*?



HARD METHOD

$|\vec{E}| = \frac{\Delta V}{\Delta d} = \frac{5.00\times10^4}{0.75m} = 66{,}666.\bar{6}\ N/C$

$\vec{E} = \frac{\vec{F}}{q}$ or $\vec{F} = q\vec{E}$
$= (20 \times 1.60\times10^{-19})(66{,}666.\bar{6})$
$= 2.1\bar{3}\times10^{-13}\ N$

$W = F_{\parallel} d$
$= (2.1\bar{3}\times10^{-13})(0.40)$
$= 8.5\bar{3}\times10^{-14}\ J$

Second movement
$W = F_{\parallel} d$
$= (0)(0.3)$
$= 0\ J$

$\boxed{\text{Total} = 8.5\bar{3}\times10^{-14}\ J}$

EASY METHOD

Because uniform force

$\Delta E_p = q\Delta V$
$= (20\times1.60\times10^{-19})(5\times10^4)$
$= 1.60\times10^{-13}\ J$
between two plates.

However, we are moving charge $\frac{40}{75}$ of the distance.

So $W = \frac{40}{75}(1.60\times10^{-13}\ J)$

$\boxed{= 8.5\bar{3}\times10^{-14}\ J}$