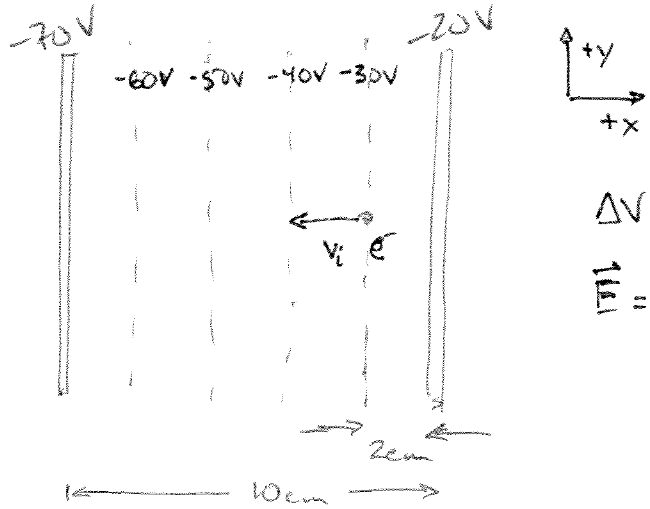
General Problem Solving Guide

Name: KEY
Lab Time:
Date: TEST 3
Test Code:
Problem #: 21

List given information, define variables, sketch picture:

[2]



$\Delta V = 50V$

$\vec{E} = -\frac{\Delta V}{\Delta x}\hat{x} = -\frac{50V}{0.1m}\hat{x} = -500\frac{V}{m}\hat{x}$

↑ constant $\vec{E}$ which gives constant $\vec{F}$ and $\vec{a}$

$v_i = 100 m/s$

$m_e = 9.11 \times 10^{-31} kg$

$q_e = -1.602 \times 10^{-19} C$

Simplify question, list target quantity:

[1/2] How fast is e^- when it hits plate?
Which way does e^- move .. describe motion.

List all related quantitative relationships:

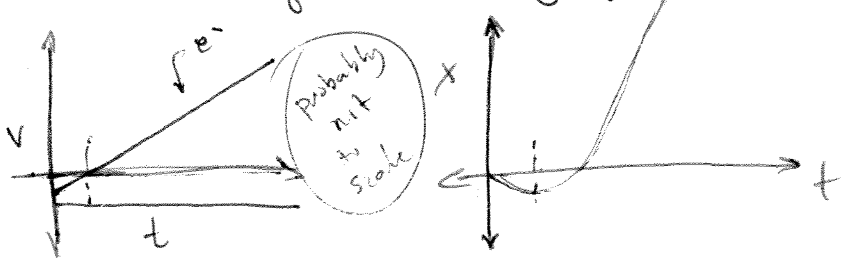
[1] $E_i = E_f$

$KE_i + PE_{q_i} = KE_f + PE_{q_f}$

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

$PE_q = qV$

From: a=constant [1]



Outline approach, sketch diagrams if needed (or sketch next to pictures above):

1] Determine Voltage needed to stop e^- (initially moving in $-\hat{x}$ direction)

[1/2]

2] What velocity when e^- hits plate

Obtain a general solution:

1] $\frac{1}{2}mv_i^2 + qV_i = \frac{1}{2}mv_f^2 + qV_f$ ($v_f = 0$, find V_f)

$\frac{mv_i^2}{2q} + V_i = V_f$

$-2.8 \times 10^{-8}V - 30V = V_f = -30V$

e^- will turn around very quickly.

$KE_i = \frac{1}{2}mv_i^2 = 4.6 \times 10^{-27}$ J

$PE_{qi} = qV = 4.8 \times 10^{-18}$ J

roughly 10^9 more PE then KE

2] e^- will hit $-20V$ plate so

$V_f = -20V$

$\frac{1}{2}mv_i^2 + qV_i = \frac{1}{2}mv_f^2 + qV_f$ (find v_f)

$\frac{1}{2}mv_i^2 + q(V_i - V_f) = \frac{1}{2}mv_f^2$

$v_i^2 + \frac{2q}{m}(V_i - V_f) = v_f^2$

$\left(100\frac{m}{s}\right)^2 + \frac{2(-1.602 \times 10^{-19})[-30V + 20V]}{9.11 \times 10^{-31} kg} = v_f^2$

$10^4 \frac{m^2}{s^2} + 3.52 \times 10^{12} \frac{m^2}{s^2} = v_f^2$

$(3.52 \times 10^{12})^{1/2} \frac{m}{s} = v_f$

$1.87 \times 10^6 \frac{m}{s} = v_f$

Check Units:

$\frac{kg\, m^2}{C\, s^2} = V = \frac{J}{C} = \frac{kg\, m}{s^2} \cdot \frac{m}{C}$ ☑

since $J = Nm = \frac{kg\, m^2}{s^2}$

$\frac{m^2}{s^2} = \frac{CV}{kg} = \frac{C}{kg}\frac{J}{C} = \frac{Nm}{kg} = \frac{kg\, m}{s^2}\frac{m}{kg} = \frac{m^2}{s^2}$ ☑

Check Limiting Cases:

$m_e \uparrow$	$V_f \uparrow$	✓
$q_e \uparrow$	$V_f \downarrow$	✓
$v_i \uparrow$	$v_f \uparrow$	(a lot more) ✓
$q \uparrow$	$v_f \uparrow$	✓
$\Delta V \uparrow$	$v_f \uparrow$	✓ $q\Delta V$
$m \uparrow$	$v_f \downarrow$	✓ $F = ma$

Obtain a numeric solution:

(i.e. plug in the numbers)

e^- will hit $-20V$ plate

$v_f = 1.87 \times 10^6 \frac{m}{s}$ (0.6% speed of light)

Why is solution reasonable? Explain.

- units check
- limiting cases check
- v_f is large but e^- are very light (not massive) particles
- $E_i = E_f$ is reasonable