Electric field 3

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Slide ③

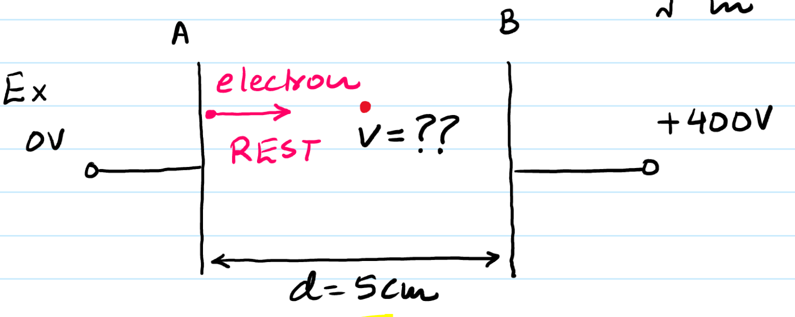
Formulas

① $E = \frac{V}{d}$ ② $E = \frac{F}{q}$

③ $V = \frac{W}{q}$ ④ $v = \sqrt{\frac{2qV}{m}}$

Note :- How else can we use the velocity formula i.e $v = \sqrt{\frac{2qV}{m}}$

Ex



(i) Cal. the speed when the electron is midway b/w the 2 plates A & B

$v = \sqrt{\frac{2qV}{m}}$

Total p.diff b/w the plates = 400 V

∴ if e^- has travelled midway Voltage = 200V

$v = \sqrt{\frac{2(1.6\times10^{-19})(200)}{9.11\times10^{-31}}}$

$v = 8.4\times10^{6}$ m/s

(ii) Cal. the speed when the electron has travelled three-quarters of the total distance

Voltage = 300V

$v = \sqrt{\frac{2(1.6\times10^{-19})(300)}{9.11\times10^{-31}}}$

$v = 1.02\times10^{7}$ m/s.

Ex. four charges $^{23}_{11}Na^{+}$, $^{40}_{20}Ca^{2+}$, $^{4}_{2}\alpha^{2+}$, $^{0}_{-1}e$

all four charges are released simultaneously, which charge particle will reach the opposite plate with greatest velocity ?

formula $v = \sqrt{\frac{2qV}{m}}$ — V constant

Since all charges will accelerate through the same voltage ∴ V = constant

note :- velocity will only depend upon $\sqrt{\frac{q}{m}}$.

$$v \propto \sqrt{\frac{q}{m}}$$

[velocity will depend on the ratio of $\frac{\text{charge}}{\text{mass}}$ (q/m)]

Sodium $_{11}^{23}Na^{+}$ $\sqrt{\frac{1}{23}}$ | Alpha $^{4}_{2}\alpha^{+2}$ $\sqrt{\frac{2}{4}}$

Calcium $^{40}_{2}Ca^{+2}$ $\sqrt{\frac{2}{40}}$ | electron $^{0}_{-1}e$ $\sqrt{\frac{1}{1840}}$

answer :- electron

Ex. for the same charges, calculate which particle will have greatest momentum ?

momentum = mass × velocity

$= m \times \sqrt{\frac{2qV}{m}}$

Simplify to get

$$\text{momentum} = \sqrt{2qmV}$$

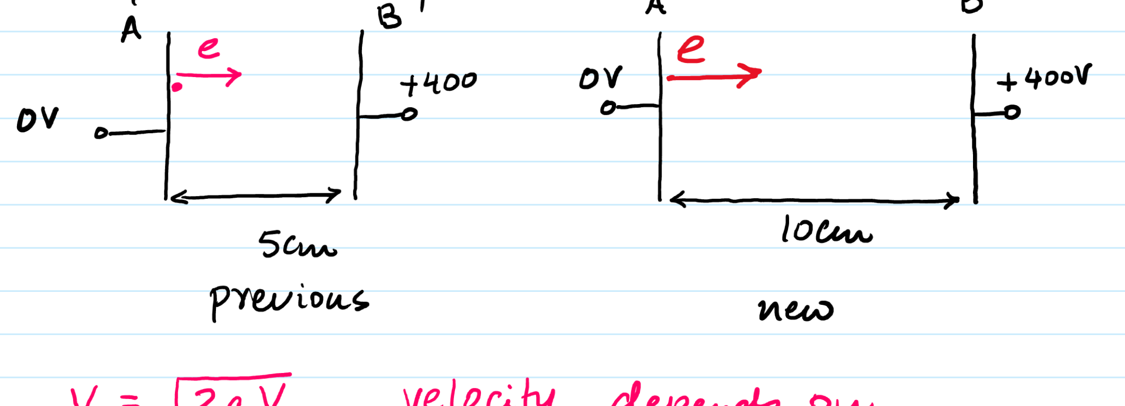
Since Voltage V = constant ∴ momentum depends upon the product of mass & charge i.e momentum $\propto \sqrt{mxq}$.

$^{23}_{11}Na^{+} = \sqrt{23\times1}$ $^{4}_{2}\alpha^{2+} = \sqrt{4\times2}$

$^{40}_{20}Ca^{2+} = \sqrt{40\times2}$ $_{-1}e = \sqrt{\frac{1}{1840}\times1}$

Ans :- Calcium

Ex. The distance b/w the two plates A and B is now doubled i.e from 5cm to 10 cm. Suggest what happens to the final velocity of the electron if it now travels b/w the 2 plates. ?



$v = \sqrt{\frac{2qV}{m}}$ velocity depends on Voltage, q & m. Since it does not depend on the distance b/w the plates ∴ final velocity remains unchanged.

Lengthy explanation :-

- $E = \frac{V}{d}$ — E half, d double
- $F = Eq$ — F half, E half
- $F = ma$ — F half, a half

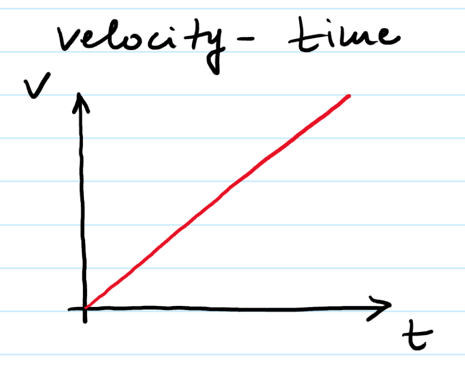
$v^2 = u^2 + 2as$ — a half, s double, so cancels out

∴ velocity / speed remains unchanged.

acceptable explanation.

(vi) Sketch the following graphs for the electron moving from one plate to the other.

(i) velocity - time



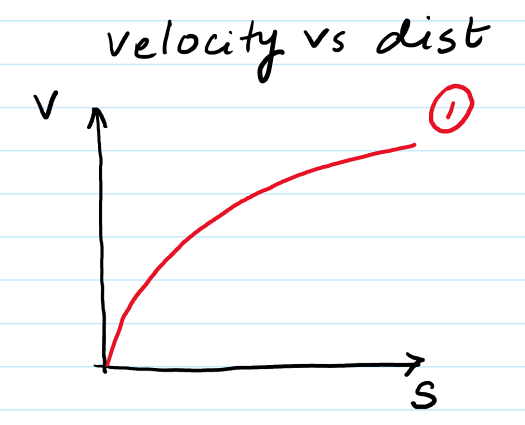
grad = acc.

E = uniform
F = Eq
F = const

F = ma
a = const.
(straight-line)

velocity vs dist

(ii)



$v^2 = u^2 + 2as$

Since u = 0 b/c electron started from rest

$v^2 = 2as$

a = constant

$v^2 \propto s$

(double) ^{2} → increases 4 times

(distance increases at a faster rate than velocity so graph must bend toward the distance axis)

(iii) K.E vs distance

K.E = W.d = F.S
if F = constant

K.E ∝ s
(straight Line)

END.