POTENTIAL DIFFERENCE AND ELECTRIC POTENTIAL $\ell 02 \frac{25}{1}$

(a) Calculate the speed of a proton that is accelerated from rest through a potential difference of 120 V.

(b) Calculate the speed of an electron that is accelerated through the same potential difference.

Given

$m_p = 1.67 \times 10^{-27}$ kg $q_e = 1.602 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg $q_p = 1.602 \times 10^{-19}$ C

$V = 120$ Volts

Change in P.E is gain in K.E

$\Delta U = q_0 \Delta V$

Now we know

$$\frac{1}{2} m v^2 = qV$$

See eq 25.10

(a) The speed of proton is

$$\frac{1}{2} m_p v_p^2 = q_p V$$

$$v_p^2 = \frac{2 q_p V}{m_p} = 2 \times \frac{1.602 \times 10^{-19} \times 120}{1.67 \times 10^{-27}}$$

$$v_p^2 = 2.3 \times 10^{10} = m^2/s^2$$

$\therefore$ $\boxed{V_p = 1.5 \times 10^5 \text{ m/s}}$

(b)

$$\frac{1}{2} m_e v_e = q_e V$$

$$v_e^2 = \frac{2 q_e V}{m_e} = 2 \times \frac{1.602 \times 10^{-19} \times 120}{9.11 \times 10^{-31}} = 4.22 \times 10^{13}$$

$\therefore$ $\boxed{V_e = 6.5 \times 10^6 \text{ m/s}}$

POTENTIAL DIFFERENCE AND ELECTRIC POT. 102 $\frac{25}{2A}$

In a tandem Vande Graff accelerator a proton is accelerated through a potential difference of 14×10^6 V. Assuming the proton starts from rest, calculate its (a) final kinetic energy in Joules, (b) final K.E. in MeV, and (c) final speed.

Given $V = 14 \times 10^6$ V, charge of proton $= 1.6 \times 10^{-19}$ C

$m_p = 1.67 \times 10^{-27}$ kg

By definition,

(a) $K.E = Vq = 14 \times 10^6 \times 1.6 \times 10^{-19}$

$\Rightarrow K.E = 2.24 \times 10^{-12}$ J

(b) Since $1\,eV = 1.6 \times 10^{-19}$ J

$\Rightarrow$

$$K.E \text{ in MeV} = \frac{2.24 \times 10^{-12}}{1.6 \times 10^{-19}} = 14 \text{ MeV}$$

(c) Since from (a)

$$\frac{1}{2} m_p v^2 = 2.24 \times 10^{-12}$$

$$v^2 = \frac{2 \times 2.24 \times 10^{-12}}{1.67 \times 10^{-27}}$$

$\Rightarrow$

$$v = \sqrt{\frac{2 \times 2.24 \times 10^{-12}}{1.67 \times 10^{-27}}} = 5.18 \times 10^7 \text{ m/s}$$

POTENTIAL DIFFERENCES IN A UNIFORM ELECTRIC FIELD.

$102\frac{25}{2}$

Suppose an electron is released from rest in a uniform electric field whose strength is 5.9×10^3 V/m. (a) Through what potential difference will it have passed after moving 1 cm? (b) How fast the electron will be moving after it has traveled 1cm.

Given
$$E = 5.9\times10^3 \ V/m$$
$$d = 1\,cm = .01\,m$$
$$m_e = 9.11\times10^{-31}\ kg$$
$$q_e = 1.602\times10^{-19}\ C$$

(a)

Now
$$V = Ed = 5.9\times10^3\times .01$$
$$V = 59 \ Volt$$

(b) we know
$$\frac{1}{2} m_e v_e^2 = q_e V$$

$\therefore$
$$v_e^2 = \frac{2 q_e V}{m_e}$$

1.38×10^{13}

$$= \frac{2\times1.602\times10^{-19}\times 59}{9.11\times10^{-31}} = 2.08\times10^{13}\ m^2/s^2$$

$$v_e = 4.56\times10^6 \ m/s$$

4.56×10^6

POTENTIAL DIFF. IN A UNIFORM ELECT. FIELD. 102 — $\frac{25}{26}$

The electric field between two charged parallel plates separated by a distance of 1.8 cm has a uniform value of 2.4×10^{4} N/C. Find the potential difference between the two plates. How much kinetic energy would be gained by a deuteron accelerating from the +ve to the negative plate.

Given $E = 2.4 \times 10^{4}$ N/C

$d = 1.8$ cm $= .018$ m

(9)

$$\Delta V = Ed = 2.4 \times 10^{4} \times 0.018$$

$$= 432 \text{ V}$$

Gain in K.E.

$$K.E = \Delta U = q\Delta V = 1.602 \times 10^{-19} \times 432$$

$$K.E = 6.92 \times 10^{-17} \text{ J}$$

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3. ELECTRICAL POTENTIAL AND POTENTIAL ENERGY DUE TO POINT CHARGES. 102 $\frac{25}{3A}$

At a distance r away from a point charge q, the electrical potential is equals to V=400 V and the magnitude of the electric field is E=150 N/C. Find the value of q and r.

Sol given $V = 400\ V$

$E = 150\ N/C$

we have $V = Er$

$\therefore \quad 400 = 150 r$

$\Rightarrow \quad r = 400/150 = 2.66\ m$

$V = K q/r$

$400 = \frac{9\times10^9 q}{2.66}$

$\Rightarrow q = \frac{400\times 2.66}{9\times10^9} = 1.19\times10^{-7}\ C$

ELECTRIC POTENTIAL.... 102 25 3B

A charge $q_1 = -9\,\mu c$ is located at the origin, and a second charge $q_2 = -1\,\mu c$ is located on the x-axis at, $x = 0.7$ m. Calculate the electric potential energy of this pair of charges.

given $q_1 = -9 \times 10^{-6}$ c

$q_2 = -1 \times 10^{-6}$ c

$r = 0.7$ m

$U = ?$

$$U = k\frac{q_1 q_2}{r} = \frac{-9 \times 10^{-6} \times -1 \times 10^{-6} \times 9 \times 10^{9}}{0.7}$$

$$U = \boxed{.116\ J}$$

OBTAINING E FROM THE ELECTRIC POTENTIAL 102 $\frac{25}{5}$

The electric potential in a certain region is given by $V = 4xz - 5y + 3z^2$ Volts. Find the magnitude of the electric field at a point (+2, -1, +3) where all distances are in meters.

Given

$$V = 4xz - 5y + 3z^2$$

$$E = ? \quad \text{at } (+2, -1, +3)$$

From eq 25.25 $\quad E_x = -\frac{dV}{dx}, \; E_y = -\frac{\partial V}{\partial y}, \; E_z = -\frac{\partial V}{\partial z}$

$$\therefore \quad E_x = -\frac{\partial V}{\partial x} = -(4z + 0 + 0)$$

$$E_x = -4z = -4 \times 3 = \boxed{-12} \text{ V/m}$$

$$E_y = -\frac{\partial V}{\partial y} = -(-5) = \boxed{5} \text{ V/m}$$

$$E_z = -\frac{\partial V}{\partial z} = -(4x - 0 + 6z)$$

$$E_z = -(4 \times 2 - 0 + 6 \times 3) = -8 - 18$$

$$= \boxed{-26} \text{ V/m}$$

Now for magnitude

$$E = \sqrt{E_x^2 + E_y^2 + E_z^2} = \sqrt{(-12)^2 + (5)^2 + (-26)^2}$$

$$E = \sqrt{144 + 25 + 676} = \sqrt{845}$$

$$E = \boxed{29.1 \text{ V/m}}$$