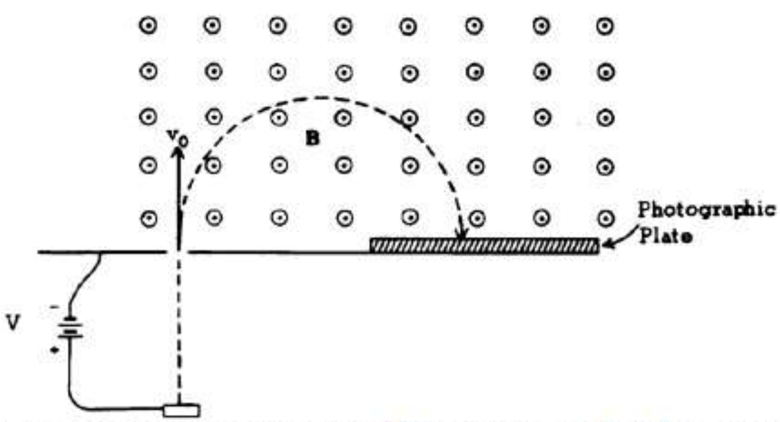
1.



1975B6. In a mass spectrometer, singly charged ^{16}O ions are first accelerated electrostatically through a voltage V to a speed v_o. They then enter a region of uniform magnetic field B directed out of the plane of the paper.

a. If singly charged ^{32}S ions are substituted for the ^{16}O ions, what will be their speed for the same accelerating voltage?

b. When ^{32}S is substituted for ^{16}O in part (a), determine by what factor the radius of curvature of the ions' path in the magnetic field changes.

(7) a) $V_o = V_s$ (1)

$K_o = K_s$ (2)

$\frac{1}{2} m_o v_o^2 = \frac{1}{2} m_s v_s^2$ (1)

$\frac{1}{2} m_o v_o^2 = \frac{1}{2} (2 m_o) v_s^2$ (2)

$v_s = \frac{v_o}{\sqrt{2}}$ (1)

(8) b) $F_B = F_C$ (1)

$q v B = \frac{m v^2}{R}$ (1) (1)

$R_o = \frac{m_o v_o}{qB}$ (1)

$R_s = \frac{m_s v_s}{qB} = \frac{2 m_o \frac{v_o}{\sqrt{2}}}{qB} = \frac{2}{\sqrt{2}} \frac{m_o v_o}{qB}$ (1) (1) (1)

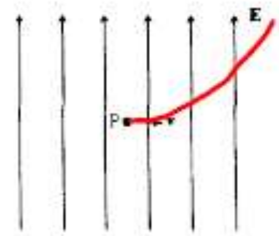
so $R_s = \sqrt{2} R_o$ (1)

Determine the magnitude and direction of the force on a proton in each of the following situations. Describe qualitatively the path followed by the proton in each situation and sketch the path on each diagram. Neglect gravity.

(a) The proton is released from rest at the point P in an electric field **E** having intensity 10^4 newtons per coulomb and directed up in the plane of the page as shown below.

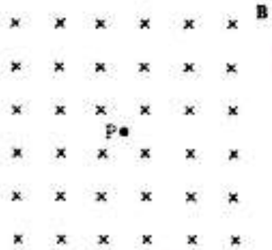
p^+ FEELS F IN DIRECTION of E.

(b) In the same electric field as in part (a), the proton at point P has velocity $v = 10^5$ meters per second directed to the right as shown below.



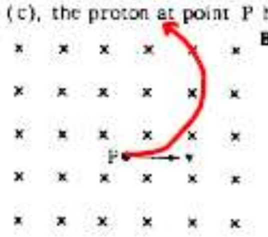
-PARABOLIC PATH; ONLY F IS VERTICAL.

(c) The proton is released from rest at point P in a magnetic field **B** having intensity 10^{-1} tesla and directed into the page as shown below.

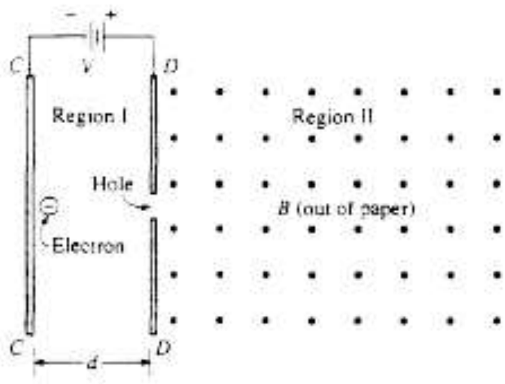


NO MOTION: $v_i = 0$ SO $F = qvB = 0$

(d) In the same magnetic field as in part (c), the proton at point P has velocity $v = 10^5$ meters per second directed to the right as shown below.



CIRCULAR PATH UPWARDS: F IS $\perp$ TO v & B, CAUSES F_c.



a) $V = \frac{EPE}{q} = \frac{EPE}{e}$

$EPE = KE = \frac{1}{2} m v^2$

i) $eV = \frac{1}{2} m v^2$

$v_0 = \sqrt{\frac{2eV}{m}}$

ii) $F = ma = eE = eV/d$

$$a = \frac{eV}{md}$$

In region I shown above, there is a potential difference V between two large, parallel plates separated by a distance d. In region II, to the right of plate D, there is a uniform magnetic field B pointing perpendicularly out of the paper. An electron, charge $-e$ and mass m, is released from rest at plate C as shown, and passes through a hole in plate D into region II. Neglect gravity.

(a) In terms of e, V, m, and d, determine the following.

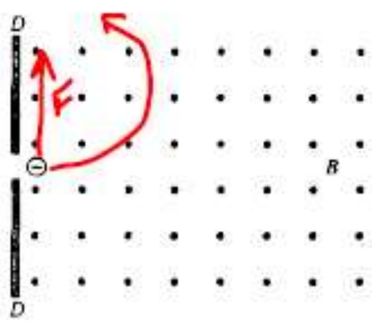
i. The speed v_0 of the electron as it emerges from the hole in plate D

ii. The acceleration of the electron in region I between the plates

(b) On the diagram below do the following.

i. Draw and label an arrow to indicate the direction of the magnetic force on the electron as it enters the constant magnetic field.

ii. Sketch the path that the electron follows in region II.

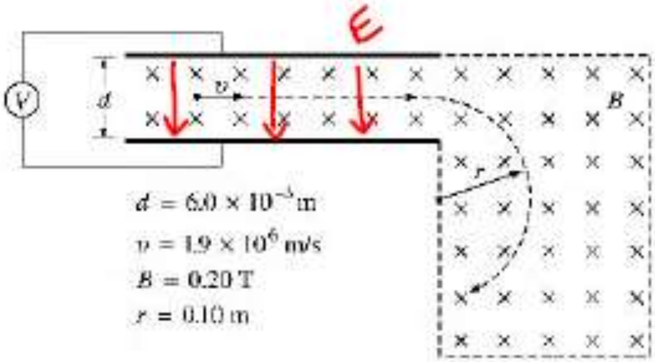


(c) In terms of e, B, V, and m, determine the magnitude of the acceleration of the electron in region II.

$\Sigma F = F_{MAG} = ma$

$evB = ma$

$$a = \frac{evB}{m} = \frac{e\sqrt{\frac{2eV}{m}}\,B}{m} = \frac{eB}{m}\sqrt{\frac{2eV}{m}}$$



7. (10 points)

A particle with unknown mass and charge moves with constant speed $v = 1.9 \times 10^6$ m/s as it passes undeflected through a pair of parallel plates, as shown above. The plates are separated by a distance $d = 6.0 \times 10^{-3}$ m, and a constant potential difference V is maintained between them. A uniform magnetic field of magnitude $B = 0.20$ T directed into the page exists both between the plates and in a region to the right of them as shown. After the particle passes into the region to the right of the plates where only the magnetic field exists, its trajectory is circular with radius $r = 0.10$ m.

(a) What is the sign of the charge of the particle? Check the appropriate space below.

__ Positive X Negative __ Neutral __ It cannot be determined from this information.

Justify your answer. F IS DOWN, SO LEFT HAND RULE FITS...

✓(b) On the diagram above, clearly indicate the direction of the electric field between the plates.

(c) Determine the magnitude of the potential difference V between the plates.

(d) Determine the ratio of the charge to the mass (q/m) of the particle.

c) $V = Ed \rightarrow V = vBd$
$(F_E = F_B,\ qE = qvB)$
$= (1.9\times10^6)(0.2T)(6\times10^{-3}m)$
$V = 2300V$

d) $F_c = F_B$
$\frac{mv^2}{r} = qvB$
$\frac{v}{rB} = \frac{q}{m} = \frac{1.9\times10^6}{(.1)(.2)} = 9.5\times10^7 \text{ C/kg}$

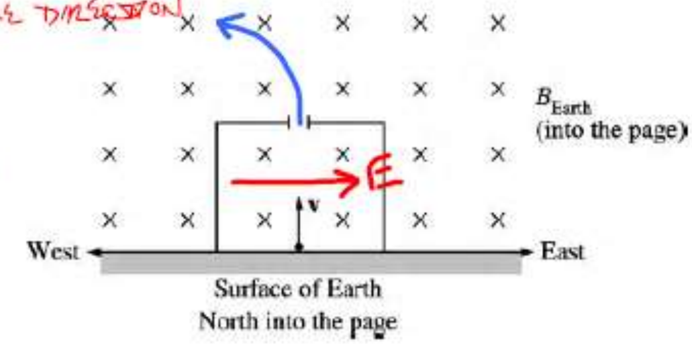
END OF EXAMINATION

I ♡ DT

- MO

a) $F_B = F_E$
F_E & E ARE IN SAME DIRECTION

b) $F_B = F_E$
$ev B_{EARTH} = eE$
$v = \frac{E}{eB}$



5. (10 points)

A proton of mass m_p and charge e is in a box that contains an electric field E, and the box is located in Earth's magnetic field B_{Earth}. The proton moves with an initial velocity **v** vertically upward from the surface of Earth. Assume gravity is negligible.

(a) On the diagram above, indicate the direction of the electric field inside the box so that there is no change in the trajectory of the proton while it moves upward in the box. Explain your reasoning.

(b) Determine the speed of the proton while in the box if it continues to move vertically upward. Express your answer in terms of the fields and the given quantities.

The proton now exits the box through the opening at the top.

(c) On the figure on the previous page, sketch the path of the proton after it leaves the box.

(d) Determine the magnitude of the acceleration a of the proton just after it leaves the box, in terms of the given quantities and fundamental constants.

d) $\Sigma F = ma$
$evB = ma$
$a = \frac{ev B_{EARTH}}{m_p}$