■ Key ■

First Name:______________________________ Last Name:______________________________

L01 – Worksheet – The Electron

Textbook Questions

Pg 756 #1: A beam of electrons passes undeflected through a 2.50-T magnetic field at right angles to a 60-kN/C electric field. How fast are the electrons travelling?

$|\vec{B}| = 2.50T$

$|\vec{E}| = 60\times10^3$ N/C

If undeflected, then $\vec{F}_{net} = 0$

so $|\vec{F}_e| = |\vec{F}_m|$

$|\vec{E}|q = |\vec{B}|qv$

$v = \frac{|\vec{E}|}{|\vec{B}|}$ if travelling undeflected.

$v = \frac{60.0\times10^3 \text{ N/C}}{2.50T} = 24{,}000 \text{ m/s}$

Pg 756 #2: What magnitude of electric field will keep protons from being deflected while they move at a speed of 1.0×10^5 m/s through a 0.05-T magnetic field?

$v = 1.0\times10^5$ m/s

$|\vec{B}| = 0.05T$

$|\vec{E}| = ?$

$|\vec{F}_e| = |\vec{F}_m|$

$|\vec{E}|q = |\vec{B}|qv$

$|\vec{E}| = (0.05T)(1.0\times10^5 \text{ m/s})$

$|\vec{E}| = 5000$ N/C

Pg 756 #3: What magnitude of magnetic field will stop ions from being deflected while they move at a speed of 75 km/s through an electric field with a magnitude of 150 N/C?

$v = \frac{75 \text{ km}}{s} \cdot \frac{1000 \text{ m}}{1 \text{ km}} = 75{,}000 \text{ m/s}$

$|\vec{E}| = 150$ N/C

$|\vec{B}| = ?$

If undeflected... $\vec{F}_{net} = 0$

$|\vec{F}_e| = |\vec{F}_m|$

$|\vec{E}|q = |\vec{B}|qv$

$|\vec{E}| = |\vec{B}|v$

$150 \text{ N/C} = |\vec{B}|(75{,}000 \text{ m/s})$

$|\vec{B}| = 0.002$ T

KEY

Pg 758 #1: Find the charge-to-mass ratio for an ion that travels in an arc of radius 1.00 cm while moving at 1.0 x 10^6 m/s perpendicular to a 1.0-T magnetic field.

$r = 1.00\times10^{-2}$ m
$v = 1.0\times10^{6}$ m/s
$|\vec{B}| = 1.0$ T

$$|\vec{F}_c| = |\vec{F}_m|$$
$$\frac{mv^2}{r} = qv|\vec{B}|$$
$$\frac{mv}{r} = q|\vec{B}|$$
$$\frac{m(1.0\times10^{6}\,m/s)}{1.0\times10^{-2}\,m} = q(1.0T)$$
$$m(1.0\times10^{8}) = q$$
$$\frac{q}{m} = 1.0\times10^{8}\,\frac{C}{kg}$$

Pg 758 #2: Find the speed of an electron moving in an arc of radius 0.10 m perpendicular to a magnetic field with a magnitude of 1.0 x 10^{-4} T.

$v = ?$
$r = 0.10$ m
$|\vec{B}| = 1.0\times10^{-4}$ T
$q = 1.60\times10^{-19}$ C
$m_e = 9.11\times10^{-31}$ kg

$$|\vec{F}_c| = |\vec{F}_m|$$
$$\frac{mv^2}{r} = qv|\vec{B}|$$
$$\frac{mv}{r} = q|\vec{B}|$$

$$\frac{(9.11\times10^{-31}kg)v}{0.10m} = (1.60\times10^{-19}C)(1.0\times10^{-4})$$
$$v = 1.756\times10^{6}\,m/s$$

Pg 758 #3: A carbon-12 ion has a charge-to-mass ratio of 8.04 x 10^6 C/kg. Calculate the radius of the ion's path when the ion travels at 150 km/s perpendicular to a 0.50-T magnetic field.

$\frac{q}{m} = 8.04\times10^{6}\,\frac{C}{kg}$
$r = ?$
$v = 150{,}000$ m/s
$|\vec{B}| = 0.50$ T

$$|\vec{F}_c| = |\vec{F}_m|$$
$$\frac{mv^2}{r} = qv|\vec{B}|$$
$$\frac{mv}{r} = q|\vec{B}|$$
$$\frac{v}{r} = \left(\frac{q}{m}\right)|\vec{B}|$$
$$\frac{150{,}000\,m/s}{r} = (8.04\times10^{6}\,\frac{C}{kg})(0.50T)$$
$$150{,}000 = (4.02\times10^{6})r$$
$$r = 3.73\times10^{-2}\,m$$

KEY

Pg 760 #4: A beam of electrons enters a vacuum chamber that has a 100-kN/C electric field and a 0.250-T magnetic field.

a. Sketch an orientation of electric and magnetic fields that will let the electrons pass undeflected through the chamber.

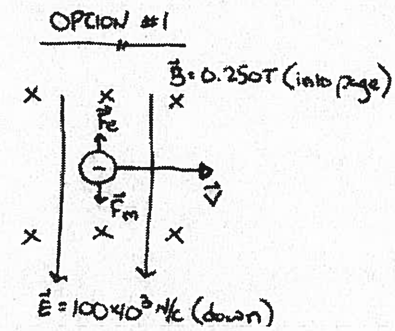
$|\vec{E}| = 100\times10^{3}$ N/C

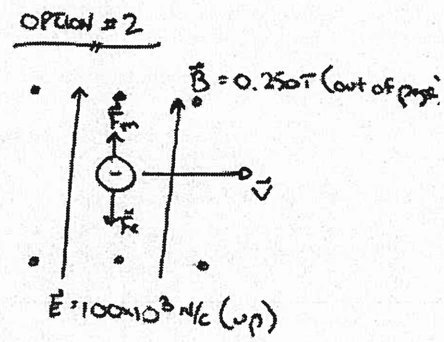
$|\vec{B}| = 0.250$ T

$q = 1.60\times10^{-19}$ C

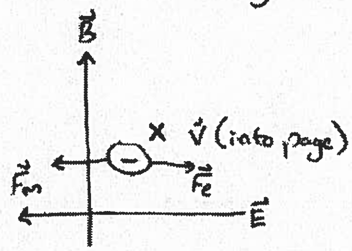
$m_e = 9.11\times10^{-31}$ kg

$v = ?$





These are the two easiest to draw, since $\vec{F_e}$ and $\vec{F_m}$ are in the plane of the paper. You could always do something weird like:



... but I really wouldn't recommend it. As a rule, it is much easier to just draw $\vec{B}$ going into or out of the page for questions like this, and have the electron travelling right or left (or possibly even up or down).

b. At what speed would electrons pass undeflected through the fields in part (a)?

If undeflected, $|\vec{E}| = |\vec{B}|$

$q|\vec{E}| = qv|\vec{B}|$

$|\vec{E}| = v|\vec{B}|$

100×10^{3} N/C $= v(0.250\text{T})$

$v = 4.00\times10^{5}$ m/s

Key

Pg 760 #5: Electrons are observed to travel in a circular path of radius 0.040 m when placed in a magnetic field of strength 0.0025 T. How fast are the electrons moving?

$r = 0.040\,m$

$|\vec{B}| = 0.0025\,T$

$q = 1.60 \times 10^{-19}\,C$

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

$v = ?$

$$|\vec{F}_c| = |\vec{F}_m|$$

$$\frac{mv^2}{r} = qv|\vec{B}|$$

$$\frac{mv}{r} = q|\vec{B}|$$

$$\frac{(9.11 \times 10^{-31}\,kg)v}{0.040\,m} = (1.60 \times 10^{-19}\,C)(0.0025\,T)$$

$$v = 1.756 \times 10^{7}\,m/s$$

Pg 760 #6: How large a magnetic field is needed to deflect a beam of protons moving at 1.50 x 10^5 m/s in a path of radius 1.00 m?

$|\vec{B}| = ?$

$q = +1.60 \times 10^{-19}\,C$

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

$v = 1.50 \times 10^{5}\,m/s$

$r = 1.00\,m$

$$|\vec{F}_c| = |\vec{F}_m|$$

$$\frac{mv^2}{r} = qv|\vec{B}|$$

$$\frac{mv}{r} = q|\vec{B}|$$

$$\frac{(1.67 \times 10^{-27}\,kg)(1.50 \times 10^{5}\,m/s)}{(1.00\,m)} = (1.60 \times 10^{-19}\,C)|\vec{B}|$$

$$|\vec{B}| = 1.5656 \times 10^{-3}\,T$$

KEY

L01 – The Electron (Basic Concepts)

Q765: In which fields will a beam of electrons experience a force?

a. Electric and magnetic only
b. Electric and gravitational only
c. Magnetic and gravitational only
(d.) Electric, magnetic, and gravitational

Q767: Cathode rays can be deflected by

"Cathode ray" = electron

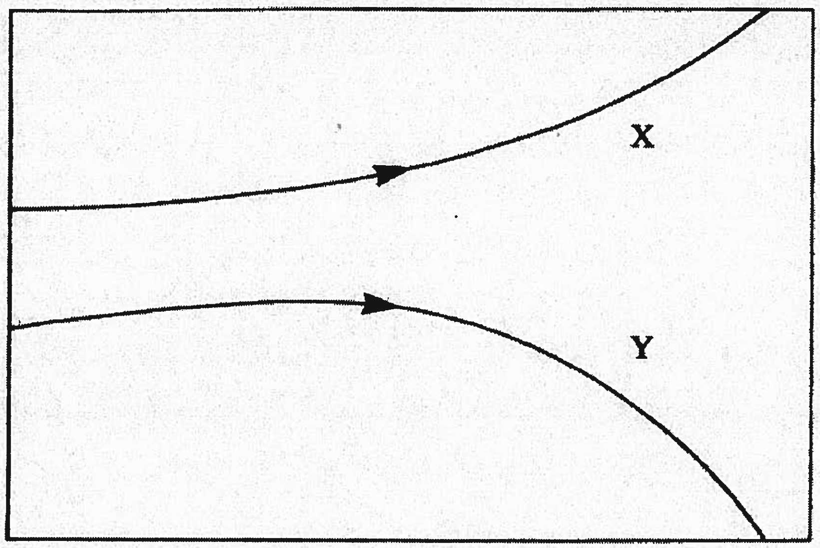
(a.) Electric or magnetic fields
b. Magnetic fields only
c. Ultraviolet radiation
d. Electric fields only

Q768: The FALSE statement regarding cathode rays is that

a. Cathode rays can be accelerated by electric and gravitational fields
(b.) Magnetic fields similarly affect visible light beams and cathode rays   Affect moving charged particles.
c. Some chemical reactions are similarly affected by cathode rays and by visible light beams
d. The nature of the cathode material does not affect the charges or the masses of the rays emitted   All electrons.

KEY

Use the following information to answer Q772:



This diagram shows the paths of two charged particles travelling from left to right perpendicular to a magnetic field.

Q772: A necessary conclusion from this diagram is that the particles

a. Have different masses
b. Travel at different speeds
c. Have charges of opposite sign
d. Have different amounts of charge

Key

Use the following information to answer Q775:

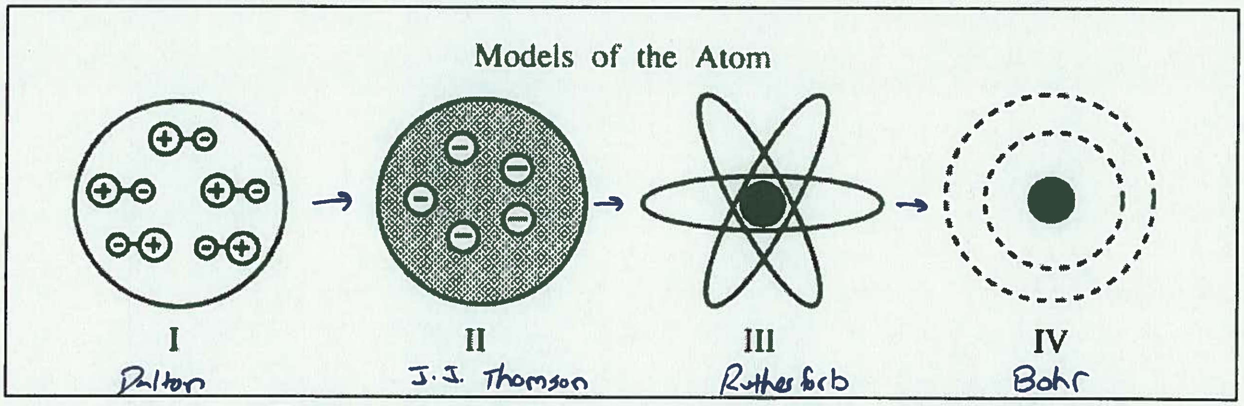


Diagram actually in correct order! Not always the case.

Q775: Thomson's model of the atom is best represented by diagram

a. I
(b.) II
c. III
d. IV

L01 – The Electron (Charge to Mass Ratio)

Q782: A charged particle used in an experiment with Thomson's apparatus enters a magnetic field of 0.20T at a speed of 5.0×10^5 m/s and is curved into a circular orbit with a 5.0 cm radius. The charge-to-mass ratio of this particle is

a. 1.0×10^6 C/kg
b. 2.5×10^6 C/kg
c. 2.5×10^7 C/kg
(d.) 5.0×10^7 C/kg

$F_c = F_m$

$\frac{mv^2}{r} = qvB$

$\frac{mv}{r} = qB$

$\frac{mv}{rB} = q$

$\frac{v}{rB} = \frac{q}{m}$

$\frac{q}{m} = \frac{v}{rB}$

$= \frac{(5.0\times10^5)}{(5\times10^{-2})(0.20)}$

$= 5.0\times10^7$ C/kg

Q783: What is the charge-to-mass ratio of a particle travelling at 2.29×10^6 m/s perpendicularly to a magnetic field of intensity 0.200 T if its circular path has a radius of 12.0 cm?

a. 5.50×10^4 C/kg
b. 1.37×10^6 C/kg
c. 3.82×10^6 C/kg
(d.) 9.54×10^7 C/kg

$F_c = F_m$

$\frac{mv^2}{r} = qvB$

$\frac{mv}{r} = qB$

$\frac{q}{m} = \frac{v}{rB}$

$= \frac{(2.29\times10^6)}{(12\times10^{-2})(0.2)}$

$= 9.54\times10^7$ C/kg

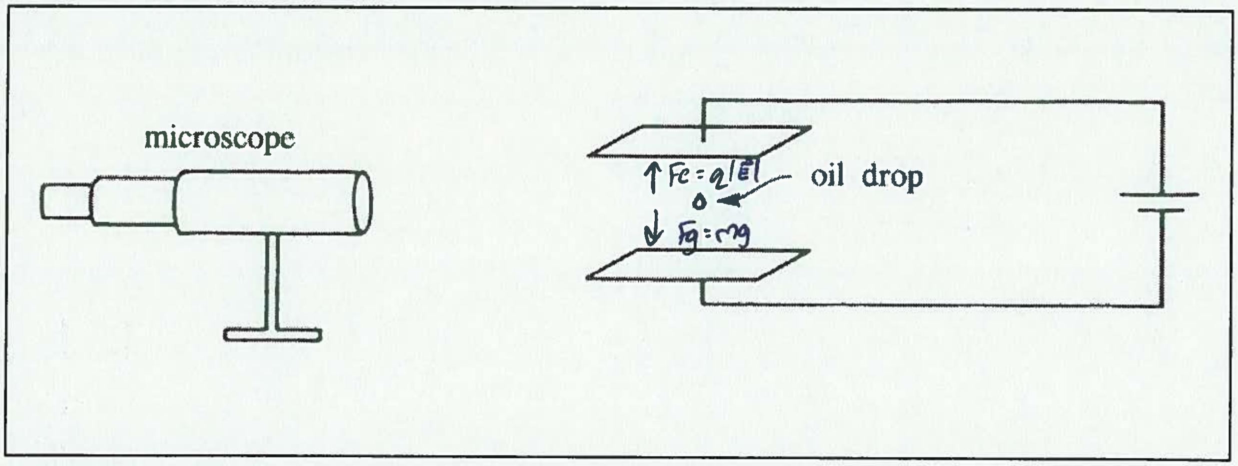
KEY

L01 – The Electron (Millikan Oil Drop)

Q797: In Millikan's oil drop experiment, the electrical force was balanced by the

a. Gravitational force
b. Magnetic force
c. Centripetal force
d. Nuclear force

Use the following information to answer Q800:



Q800: Which equation is associated with the apparatus in the diagram?

a. $q_e|\vec{E}| = mg$
b. $E_{k(\max)} = q_e V_{stop}$
c. $q_e|\vec{E}| = q_e vB$
d. $q_e vB = mv^2/r$