Physics 30 – Lesson 26
Cathode Rays

Possible 60 / 50

1) /2

$F_m = F_E$

$qvB_\perp = q\left|\vec{E}\right|$

$v = \dfrac{\left|\vec{E}\right|}{B_\perp}$

2) /2

$F_c = F_m$

$\dfrac{mv^2}{r} = qvB_\perp$

$\dfrac{q}{m} = \dfrac{v}{B_\perp r}$

3) /4

$v = 4.0\times10^7\ {}^{m}\!/_{s}$

$B_\perp = 1.0\times10^{-4}T$

$d = 0.020m$

$F_E = F_m$

$q\left|\vec{E}\right| = qvB_\perp$

$\dfrac{V}{d} = vB_\perp$

$V = vdB_\perp$

$V = 4.0\times10^7\ {}^{m}\!/_{s}(0.020m)(1.0\times10^{-4}T)$

$\boxed{V = 80V}$

4) /4

$m = 6.65\times10^{-27}kg$

$q = 3.20\times10^{-19}C$

$v = 5.0\times10^7\ {}^{m}\!/_{s}$

$B_\perp = 2.0T$

$r = ?$

$F_C = F_m$

$\dfrac{mv^2}{r} = qvB_\perp$

$r = \dfrac{mv}{qB_\perp}$

$r = \dfrac{6.65\times10^{-27}kg(5.0\times10^7\ {}^{m}\!/_{s})}{3.20\times10^{-19}C(2.0T)}$

$\boxed{r = 0.52m}$

5) /3

$\dfrac{q}{m} = 1.5\times10^5 C/kg$

$m = 2.0\times10^{-15}kg$

$q = \dfrac{q}{m}\times m$

$q = 1.5\times10^5\ \frac{C}{kg}\times 2.0\times10^{-15}kg$

$\boxed{q = 3.0\times10^{-10}C}$

6)

/4

$m = 1.67\times10^{-27}\,kg$
$q = 1.60\times10^{-19}\,C$
$v = 5.60\times10^{5}\ {}^{m}\!/_{s}$
$r = 7.50\times10^{-3}\,m$
$B_{\perp} = ?$

$F_c = F_m$

$\frac{mv^2}{r} qvB_{\perp}$

$B_{\perp} = \frac{mv}{qr}$

$B_{\perp} = \frac{1.67\times10^{-27}\,kg(5.00\times10^{5}\ {}^{m}\!/_{s})}{1.60\times10^{-19}\,C(7.50\times10^{-3}\,m)}$

$\boxed{B_{\perp} = 0.779T}$

7)

/3

$F_m = F_E$

$qvB_{\perp} = q\left|\vec{E}\right|$

$\left|\vec{E}\right| = v \cdot B_{\perp}$

$\left|\vec{E}\right| = 7.50\times10^{5}\ {}^{m}\!/_{s}\,(0.220T)$

$\boxed{\left|\vec{E}\right| = 1.65\times10^{5}\ \frac{V}{m}}$

8)

/6

$B_{\perp} = 0.360T$
$r = 0.0820m$
$m = 6.65\times10^{-27}\,kg$
$q = 3.20\times10^{-19}\,C$
$v = ?$

$F_c = F_m$

$\frac{mv^2}{r} = qvB_{\perp}$

$v = \frac{qB_{\perp}r}{m}$

$v = \frac{(3.20\times10^{-19}\,C)(0.360T)(0.0820m)}{6.65\times10^{-27}\,kg}$

$v = 1.4205\times10^{6}\ {}^{m}\!/_{s}$

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

$E_k = \frac{1}{2}(6.65\times10^{-27}\,kg)(1.4205\times10^{6}\ {}^{m}\!/_{s})^2$

$\boxed{E_k = 6.71\times10^{-15}\,J}$

9)

/4

$v = 4.75\times10^{7}\ {}^{m}\!/_{s}$
$q = 1.60\times10^{-19}\,C$
$m = 9.11\times10^{-31}\,kg$
$V = ?$

$E_p = E_k$

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

$V = \frac{\frac{1}{2}mv^2}{q}$

$V = \frac{\frac{1}{2}(9.11\times10^{-31}\,kg)(4.75\times10^{7}\ {}^{m}\!/_{s})^2}{1.60\times10^{-19}\,C}$

$\boxed{V = 6.42kV}$

10)

/7

$V = 1.40\times10^{3}V$

$B_{\perp} = 0.0220T$

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

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

$r = ?$

$v = ?$

$E_k = qV$

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

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

$v = \sqrt{\frac{2(1.60\times10^{-19}C)(1400V)}{9.11\times10^{-31}kg}}$

$v = 2.22\times10^{7}\ {}^{m}\!/\!_{s}$

$F_C = F_m$

$\frac{mv^2}{r} = qvB_{\perp}$

$r = \frac{mv}{qB_{\perp}}$

$r = \frac{9.11\times10^{-31}kg(2.22\times10^{7}\ {}^{m}\!/\!_{s})}{1.60\times10^{-19}C(0.0220T)}$

$\boxed{r = 5.74\times10^{-3}m}$

11)

/6

$F_E = F_g$

$q\left|\vec{E}\right| = mg$

$\frac{qV}{d} = mg$

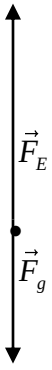
$q = \frac{mgd}{V} = \frac{0.040kg(9.81\ {}^{m}\!/\!_{s^2})(0.040m)}{1.633\times10^{16}V}$

$q = 9.61\times10^{-19}C$

# of electrons $= \frac{9.61\times10^{-19}C}{1.60\times10^{-19}C/e^{-}} = \boxed{6e^{-}}$

12)

/5



$\vec{F}_{net} = m\vec{a}$

$\vec{F}_E + \vec{F}_g = m\vec{a}$

$q\left|\vec{E}\right| + m\vec{g} = m\vec{a}$

$\frac{qV}{d} + m\vec{g} = m\vec{a}$

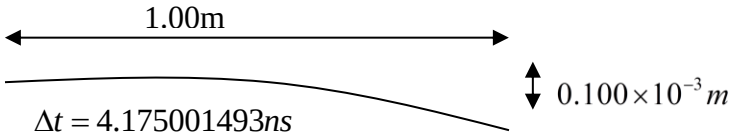
$\frac{qV}{d} = m\vec{a} - m\vec{g}$

$V = \frac{md(\vec{a} - \vec{g})}{q}$

$V = \frac{3.0\times10^{-15}kg(0.0300m)(+3.0\ {}^{m}\!/\!_{s^2} - (-9.81\ {}^{m}\!/\!_{s^2}))}{5\times1.60\times10^{-19}C}$

$\boxed{V = 1.4\times10^{3}V}$

Search for Anti-Matter



$\Delta t = 4.175001493 ns$

$B = 1.00\times10^{-3} T$

A) charge on particle
- the particle has a negative charge (left hand rule works)

B) Find charge to mass ratio
- a good, simple approximation is to treat the particle as a projectile

Bonus
/10

vertical

$a = ?$

$\Delta d = 0.100\times10^{-3} m$

$\Delta t = 4.175\times10^{-9} s$

$v_i = 0$

$$\Delta d = v\Delta t + \frac{1}{2}a\Delta t^2$$

$$a = \frac{2\Delta d}{\Delta t^2} = \frac{2(0.100\times10^{-3} m)}{(4.175\times10^{-9} s)^2}$$

$a = 1.147\times10^{13}\ {}^{m}/_{s^2}$

force magnetic = net force

$F_m = F_{net}$

$qvB_\perp = ma$

$$\frac{q}{m} = \frac{a}{vB_\perp}$$

$$\frac{q}{m} = \frac{1.147\times10^{13}\ {}^{m}/_{s^2}}{2.395\times10^{8}\ {}^{m}/_{s}}$$

$$\boxed{\frac{q}{m} = 4.79\times10^{7}\ \frac{C}{kg}}$$

-testing different q/m values for different particles we find that for an alpha particle

$$\frac{q}{m} = 4.81\times10^{7}\ \frac{C}{kg}$$

So, this particle is an anti-alpha particle (negative charge)

horizontal

$\Delta d = 1.00 m$

$\Delta t = 4.175001493\times10^{-9} s$

$$v_h = \frac{\Delta d}{\Delta t}$$

$$v_h = \frac{1.00 m}{4.175001493\times10^{-9} s}$$

$v_h = 2.395\times10^{8}\ {}^{m}/_{s}$