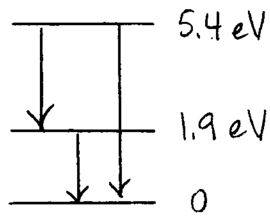
1) The drawing at the right shows the energy leverls of a hypothetical atom. List the wavelengths (in nm) of all the lines that will be seen in the line spectrum of this atom.



$E = hf = h\frac{c}{\lambda}$ $\qquad \lambda = \frac{hc}{E}$

There are 3 possible lines, with energies 1.9eV, 3.5eV and 5.4eV

$$\lambda_1 = \frac{(6.626\times10^{-34}\,J\cdot s)(3\times10^{8}\,m/s)}{(1.9eV)(1.602\times10^{-19}\,J/eV)} = 6.53\times10^{-7}\,m = 653\,nm$$

$$\lambda_2 = \frac{(\;\text{"}\;)(\;\text{"}\;)}{(3.5eV)(\;\text{"}\;)} = 354\,nm$$

$$\lambda_3 = \frac{(\;\text{"}\;)(\;\text{"}\;)}{(5.4eV)(\;\text{"}\;)} = 230\,nm$$

653nm, 354nm, 230 nm

2) Ne has 10 electrons. List the quantum numbers n, l, m_l, m_s of each of the 10 electrons for Ne atoms in the ground state.

n	l	m_l	m_s
1	0	0	$+\frac{1}{2}$
1	0	0	$-\frac{1}{2}$
2	0	0	$+\frac{1}{2}$
2	0	0	$-\frac{1}{2}$
2	1	1	$+\frac{1}{2}$
2	1	1	$-\frac{1}{2}$
2	1	0	$+\frac{1}{2}$
2	1	0	$-\frac{1}{2}$
2	1	-1	$+\frac{1}{2}$
2	1	-1	$-\frac{1}{2}$

3) The nucleus ^{110}Ag has a half-life of 2.4 minutes. $2.4\,\text{min} = 144\,\text{s}$

(*a*) Find the activity (decays per second) of a source consisting of 3×10^{10} atoms of ^{110}Ag.

$$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{0.693}{144\,\text{s}} = 4.81 \times 10^{-3}/\text{s}$$

$$A = \lambda N = (4.8 \times 10^{-3}/\text{s})(3 \times 10^{10}) = 1.44 \times 10^{8}/\text{s}$$

$$\boxed{1.44 \times 10^{8}/\text{s}}$$

(*b*) What will the activity of the source be after 6 minutes have gone by? $6\,\text{min} = 360\,\text{s}$

$$N = N_0 e^{-\lambda t} = (3 \times 10^{10}) e^{-(4.81 \times 10^{-3})(360)} = 5.3 \times 10^{9}$$

$$A = \lambda N = 2.55 \times 10^{7}/\text{s}$$

$$\boxed{2.55 \times 10^{7}/\text{s}}$$

4) Find the deBroglie wavelength of an electron with a kinetic energy of 20 eV. The electron mass is 9.11×10^{-31} kg.

$$KE = \frac{1}{2} m v^2 = \frac{(mv)^2}{2m} = \frac{p^2}{2m}$$

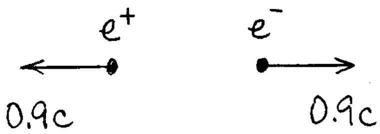
$$p = [2m \cdot KE]^{\frac{1}{2}} = [2(9.11 \times 10^{-31}\,\text{kg}) \cdot (20\,\text{eV})(1.602 \times 10^{-19}\,\text{J/eV})]^{\frac{1}{2}}$$

$$p = 2.42 \times 10^{-24}\,\text{kg} \cdot \text{m/s}$$

$$\lambda = h/p = \frac{6.626 \times 10^{-34}\,\text{J} \cdot \text{s}}{2.42 \times 10^{-24}\,\text{kg} \cdot \text{m/s}} = 2.74 \times 10^{-10}\,\text{m}$$

$$\boxed{.274\,\text{nm}}$$

5) An unstable particle, x, at rest in the lab decays spontaneously into an electron and a positron (both of which have rest mass 9.11×10^{-31} kg). In the decay the electron and the positron are emitted in opposite directions, each with speed 0.9 c.



(a) What was the mass of particle x?

Total energy is conserved $E_i = E_f$

$E_i = m_x c^2$ $\qquad$ $E_f = E_{e^+} + E_{e^-}$

$$E_{e^-} = E_0 + KE = m_0 c^2 + (\gamma - 1) m_0 c^2 = \gamma m c^2$$

$$\gamma = \left[\frac{1}{1 - v^2/c^2}\right]^{\frac{1}{2}} = \left(\frac{1}{1 - .81}\right)^{\frac{1}{2}} = 2.29$$

$$E_{e^-} = E_{e^+} = (2.29)\, m_0 c^2$$

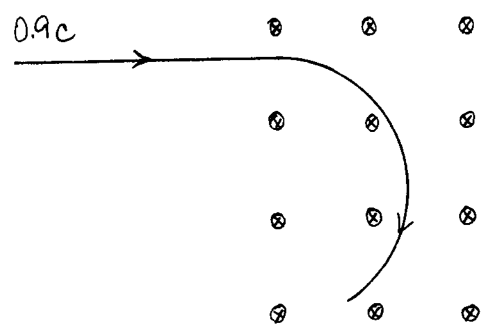
So

$$m_x \cancel{c^2} = 2 \times (2.29)\, m_0 \cancel{c^2}$$

$$m_x = (2.29) \times (2) \times (9.11 \times 10^{-31}\,\text{kg})$$

$$\boxed{4.17 \times 10^{-30}\ \text{kg}}$$

(b) Suppose the electron enters a region in which there is a uniform magnetic field of 0.8 T (into the page in the drawing). As it moves through the field the electron will follow a circular path. Find the radius of the circle.



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

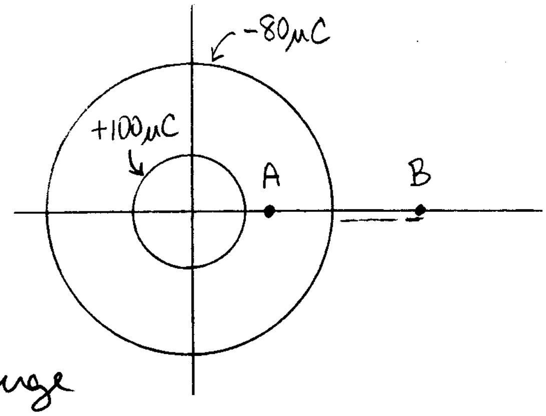
<u>But</u> we need to use the relativistic mass of the electron $m = \gamma m_0$

$$R = \frac{(2.29)(9.11 \times 10^{-31}\,\text{kg})(0.9)(2.998 \times 10^{8}\,\text{m/s})}{(1.602 \times 10^{-19}\,\text{C})(0.8\,\text{T})}$$

$$= 4.39 \times 10^{-3}\,\text{m}$$

$$\boxed{4.39\ \text{mm}}$$

6) Two concentric hollow metal spheres have radii of 20 cm and 50 cm respectively. A charge of $+100\mu C$ is placed on the smaller sphere, and a charge of $-80\mu C$ is placed on the larger one. Find the magnitude of the electric field at point A (30 cm from the center of the spheres) and at point B (80 cm from the center).



At A there is no field from the outer charge

$$E = \left(\frac{1}{4\pi\epsilon_0}\right)\frac{100\times10^{-6}C}{(0.3m)^2} = 9.99\times10^{6}\ V/m$$

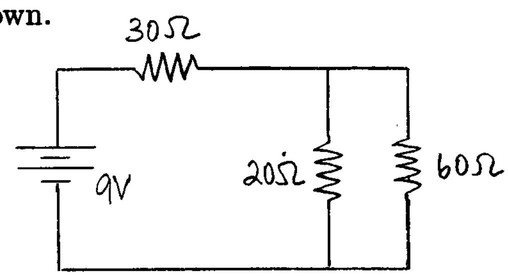
At B we get fields from both spheres. The net charge is now $+20\mu C$

$$E = \left(\frac{1}{4\pi\epsilon_0}\right)\frac{20\times10^{-6}C}{(0.8m)^2} = 2.81\times10^{5}\ V/m$$

Point A: $\boxed{9.99\times10^{6}\ V/m}$

Point B: $\boxed{2.81\times10^{5}\ V/m}$

7) Find the total current supplied by the battery in the circuit shown.



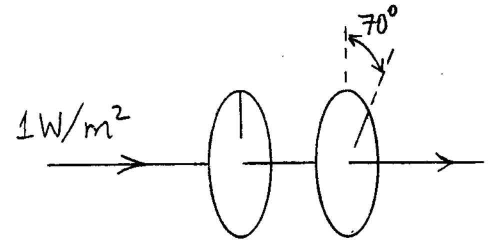
$$\frac{1}{R_{\parallel}} = \frac{1}{20\Omega} + \frac{1}{60\Omega} \Rightarrow R_{\parallel} = 15\Omega$$

$$R_{TOT} = 30\Omega + 15\Omega = 45\Omega$$

$$I = \frac{V}{R} = \frac{9V}{45\Omega} = 0.2A$$

$\boxed{0.2A}$

8) Unpolarized light of intensity 1 W/m^2 passes through a pair of linear polarizers. Find the intensity of the transmitted light if the axis of the second polarizer is rotated by 70° relative to the first.

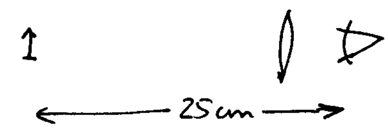


The incident light is unpolarized, so the intensity is reduced by a factor of 2 in the 1st polarizer $\Rightarrow$ $S = \frac{1}{2} W/m^2$. After passing through the second polarizer

$$S = S_0 \cos^2\theta = (0.5\ W/m^2)(\cos^2 70°)$$
$$= 0.0585\ W/m^2$$

$$\boxed{0.0585\ W/m^2}$$

9) Suppose your near point is 90 cm. What focal length would your eyeglass lenses need to have in order to read a newspaper held 25 cm in front of your eyes. Assume that the lenses are 2 cm in front of your eyes.

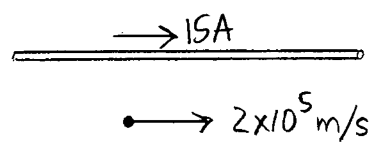


We want the object to be 25 cm in front of our eye $\Rightarrow$ 23 cm in front of the lens. We want the image to be formed at our near point, 90 cm from the eye $\Rightarrow$ 88 cm from the lens. So with $d_o = 23$ cm we want $d_i = -88$ cm

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{23cm} - \frac{1}{88cm}$$
$$f = 31.1\ cm$$

$$\boxed{31.1\ cm}$$

10) A long straight wire carries a current of 15 A. A proton is moving parallel to the wire at a speed of 2×10^5 m/s. The proton is 5 cm from the wire and directly below it. Find the magnitude of the force acting on the proton.



$$B_{wire} = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7} T{\cdot}m/A)(15 A)}{2\pi(.05 m)} = 6.0 \times 10^{-5} T$$

$$F = qvB\sin\theta = (1.602 \times 10^{-19} C)(2 \times 10^5 m/s)(6.0 \times 10^{-5} T)$$
$$= 1.92 \times 10^{-18} N$$

$$\boxed{1.92 \times 10^{-18} N}$$