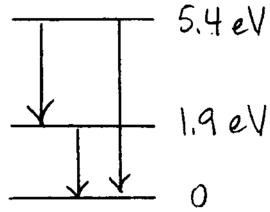
1) The drawing at the right shows the energy leverls of a hypothetical atom. List the wavelengths (in nm) of all the lines that will be seen in the line spectrum of this atom.



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

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. $2.4\,\text{min} = 144\,s$

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

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

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

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

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

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

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

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

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

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

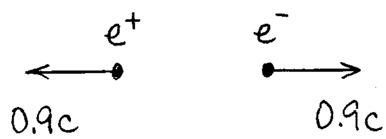
$$p = [2m \cdot KE]^{\frac{1}{2}} = [2(9.11 \times 10^{-31}\,kg) \cdot (20eV)(1.602 \times 10^{-19}\,J/eV)]^{\frac{1}{2}}$$

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

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

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

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 $\quad E_i = E_f$

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

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

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

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

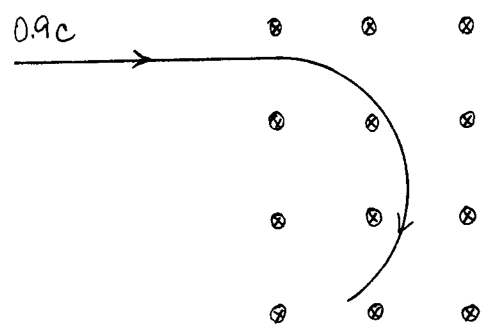
So

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

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

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

(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.



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

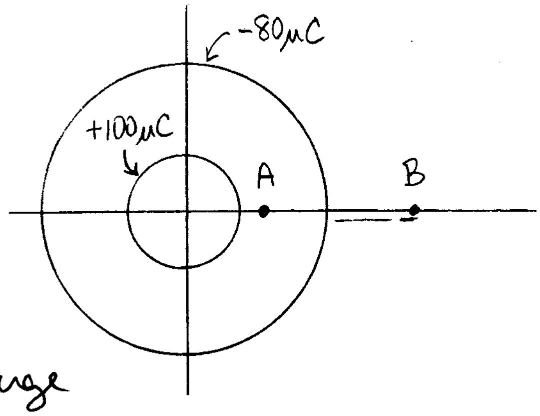
But we need to use the relativistic mass of the electron $\quad m = \gamma m_0$

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

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

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

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

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

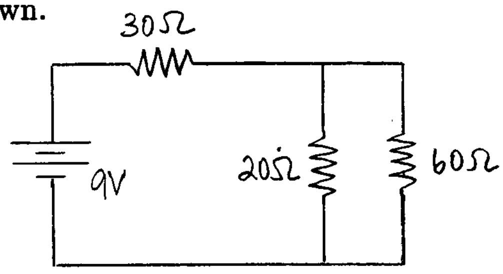
At B we get fields from both spheres. The net charge is now $+20\mu C$

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

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.



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

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

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

$\boxed{0.2\ A}$