Modern Homework 29 William Jardee

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1) a) The max accel will will be when the μ_z & B are aligned and we are in the field, which happens naturally anyways.

+4

$$F_z = \mu_x \cancel{\frac{\partial B_x}{\partial z}}^{0} + \mu_y \cancel{\frac{\partial B_y}{\partial y}}^{0} + \mu_z \frac{\partial B_z}{\partial z}$$

$$m\ddot{z} = \mu_z \frac{\partial B_z}{\partial z}$$

$$m\ddot{z} = (m_e + m_s g)\mu_B \frac{\partial B}{\partial z} \qquad m_e = 0, \quad m_s = 1/2$$

$$\ddot{z} = \frac{1}{m_e}\left(\frac{1}{2}g\right)\mu_B \frac{\partial B_z}{\partial z} \qquad g \approx 2$$

$$= \frac{1}{m_e}\mu_B \frac{\partial B_z}{\partial z} = \frac{c^2}{m_e c^2}\mu_B \frac{\partial B_z}{\partial z}$$

$$\boxed{\ddot{z} \approx 3.33 \times 10^6 \ m/s^2 \quad >> g}$$

this is why the result doesn't take the gravitational accel into account.

Unit check? $\left[\frac{1}{eV}\right]\left[\frac{m^2}{s^2}\right]\left[\frac{eV}{T}\right]\left[\frac{T}{m}\right] = \left[\frac{m}{s^2}\right]$ ✓

b) $$t_{in} = \frac{0.75\ m}{14500\ m/s} = 5.17 \times 10^{-5}\ s$$

$$t_{out} = \frac{1.25\ m}{14500\ m/s} = 8.621 \times 10^{-5}\ s$$

$$V_{f_z} = t_{in}\ddot{z} = 172.410\ m/s$$

$$z_f = \frac{1}{2}\ddot{z}\, t_{in}^2 + V_f\, t_{out} \boxed{= 0.0193\ m}$$

It will be twice this value, as one beam is deflected up, one is deflected down.

2) +3 a) $\vec{L} = \vec{L}_1 + \vec{L}_2$

we can't do the vectors, but we can do L_z

$$L_z = L_{1z} + L_{2z} = m_{\ell_1}\hbar + m_{\ell_2}\hbar = m_\ell \hbar$$

$$m_{\ell_1} + m_{\ell_2} = m_\ell$$

m_{ℓ_1} + m_{ℓ_2} can range from -1 to $+1$, so

m_ℓ can range from -2 to $+2$.

So $\boxed{\cancel{\ell=2}}$ ℓ = 0, 1, or 2. n is the number that's greater, and it allies to hydrogen only. Same applies for the rest.

b) a similar analysis can be made with the spin.

$$\vec{S} = \vec{S}_1 + \vec{S}_2$$

$$S_z = S_{z1} + S_{z2} = m_{s_1}\hbar + m_{s_2}\hbar = m_s\hbar$$

$$m_{s_1} + m_{s_2} = m_s$$

Since m_{s_1} & m_{s_2} either is $-\frac{1}{2}$ or $\frac{1}{2}$, so

m_s is either $-1, 0, 1$.

So $\boxed{S=1}$

c) the range of j is $j = |\ell - s| \ldots \ell + s$

So $\boxed{j = 1, 2, 3}$

d) $J_z = m_j\hbar = S_z + L_z = m_s\hbar + m_\ell\hbar$

$$m_j = m_s + m_\ell$$

So the range is $\boxed{-\frac{3}{2} \text{ to } \frac{3}{2}}$ by int steps.

e) adding together the two numbers give a range of -3 to 3, or a $\boxed{j=3}$

this matches what we got in c ✓

3) +4

a) $E = \frac{hc}{\lambda}$ $\Delta E = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) \Rightarrow 0.00733 \text{ eV}$

b) $\Delta U = 2\mu_s B = 2(\frac{1}{2}g)\mu_B B$ $g \approx 2$

$$\boxed{B = \frac{\Delta E}{2\mu_B} \approx 63.3 \text{ T}}$$

(3 sig figs from the number used for μ_B)