General Physics 204, Section . . . — Monday, Apr 27, 2015

Quiz #10 — The Nature of the Atom

Name:

1) CLASS(2)

$Z = 1$

In a high voltage discharge tube, a wavelength of 410.2 nm is emitted from a hydrogen atom. Find the initial and final values of the quantum number n for the electron which produces this wavelength. *Hint: Think about the maximum and minimum you get for each series, and try to see if this specific wavelength is in a range.* $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ $\lambda^* = 410.2$ nm $\rightarrow \frac{1}{\lambda^*} = 0.2438\ R$.

Lyman: $n_1 = 1 \rightarrow 1/\lambda^L_{min} = R(1-0)$, $1/\lambda^L_{max} = R(1-\frac{1}{4}) \rightarrow \lambda^L_{max} < \lambda^*$

Balmer: $n_1 = 2 \rightarrow 1/\lambda^B_{min} = R(\frac{1}{4}-0)$, $1/\lambda^B_{max} = R(\frac{1}{4}-\frac{1}{9}) \rightarrow \lambda^B_{min} < \lambda^* < \lambda^B_{max}$ so $n_1 = 2$ ✓

Paschen: $n_1 = 3 \rightarrow 1/\lambda^P_{min} = R(\frac{1}{9}-0)$, $1/\lambda^P_{max} = R(\frac{1}{9}-\frac{1}{16}) \rightarrow \lambda^* < \lambda^P_{min}$

⋮

Solving for n_2: $0.2438 = \frac{1}{4} - \frac{1}{n_2^2} \rightarrow n_2 = 6$.

2) CLASS(2)

We know, using conservation of the angular momentum, that electrons when by absorbing/emitting a photon change their quantum number n, they have to change their quantum number l by ± 1.

a) Can an electron go from $1s$ to $3d$ absorbing one photon? How about $3s$ to $4p$?

b) An electron changes n from 2 to 1. Find the l quantum number before and after emitting the photon.

a) 1s : $n=1$, $l=0$, 3d : $n=3$, $l=2$ $\rightarrow \Delta l = 2$ not possible w/ a photon.
3s : $n=3$, $l=0$, 4p : $n=4$, $l=1$ $\rightarrow \Delta l = 1$ possible " " ".

b) Finally $n=1$ so $l=0$. So initially electron can only have $l=1$.

3) CLASS(2)

The orbital quantum number for an electron in a Li^{2+} atom is $l = 3$. What are the possible n quantum number for this electron? What are the possible m_l quantum number for this electron? Find the maximum and minimum wavelengths of photons emitted when this electron jumps from a possible n to a lower one.

$n = 4, 5, 6, \ldots$ $l = 3$ $m_l = -3, \ldots, 3$

$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$, Li^{2+} is H-like, i.e. it has only one electron & $Z = 3$

max energy photon: $n = \infty$, $l = 3$
$n = 3$, $l = 2$ Conservation of L $(\Delta l = \pm 1)$
$\frac{1}{\lambda_{min}} = R \cdot 9 \cdot \left(\frac{1}{9} - 0\right) = R \rightarrow \lambda_{min} = R^{-1}$.

min energy photon: $n = \infty$, $l = 3$
$n = \infty - 1$, $l = 2$ or 4 Conservation of L $(\Delta l = \pm 1)$
$\frac{1}{\lambda_{max}} = R \cdot 9 \cdot (0 - 0) = 0 \rightarrow \lambda_{max} = \infty$.