Maya's guest lecture on structure of Hydrogen

Useful results

Bohr radius: $\frac{4\pi\epsilon_0\hbar^2}{m_e e^2} = 0.0529\text{ nm}$

$$E_n = -\frac{m_e}{2\hbar^2}\left(\frac{e^2}{4\pi\epsilon_0}\right)^2\frac{1}{n^2}$$

$\hbar c = 197.37\text{ eV nm}$

$hc = 1240\text{ eV nm}$

$k_e = \frac{e^2}{4\pi\epsilon_0}$, $\frac{k_e}{\hbar c} = \frac{1}{137.04}$

I Matt's questions in more depth

II Derive λ of H-atom

III Examples

I. ① Why doesn't H radiate constantly? Electron's are not moving in the traditional sense – they are in stationary states and so they need not radiate.

② Why does an H-atom sometimes emit photons (γ's)? The electron can be excited in to higher energy states and emit radiation γ's, to come back down.

③ Why particular λ's?

$$E_\gamma = hf = \left| -\frac{m_e}{2\hbar^2} k_e^2 \left(\frac{1}{n_i^2} - \frac{1}{n_f^2} \right) \right|$$

$$= \frac{m_e}{2\hbar^2} k_e^2 \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

also, $\lambda = \frac{c}{f} \Rightarrow f = \frac{c}{\lambda}$

So $E_\gamma = \frac{\hbar 2\pi c}{\lambda} \Rightarrow \frac{1}{\lambda} = \frac{E_\gamma}{\hbar 2\pi c}$

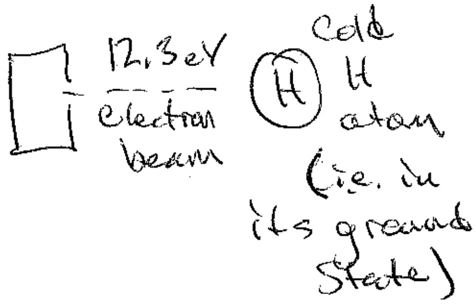
So,

$$\frac{1}{\lambda} = \frac{m_e}{4\pi\hbar^3} \left(\frac{e^2}{4\pi\epsilon_0} \right)^2 \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$

$$= R \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$

We find $\boxed{R = \frac{m_e}{4\pi\hbar^3} \left(\frac{e^2}{4\pi\epsilon_0} \right)^2 = 1.097 \times 10^7 \ m^{-1}}$

III Example 1:



$12.3eV - 13.6eV = -1.3eV$

So, the most energy that can be absorbed gives $E_3 = -1.5eV$

Then the allowed transitions are

$E_3 \rightarrow E_2$ Balmer Series

$E_3 \rightarrow E_1$ Lyman Series

<u>$E_{3\to 2}$:</u> E_γ = ~~(1)(13.6eV)~~ 1.9eV

$$\lambda = \frac{hc}{E_\gamma} = \frac{1240\,eV\,nm}{1.9\,eV} = 656\,nm$$

red.

<u>$E_{3\to 1}$:</u> $E_\gamma = 12.1\,eV$

$$\lambda = \frac{1240\,eV\,nm}{12.1\,eV} = 103\,nm$$

Ultraviolet