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Office Hour: Tu 5-6pm Location: Bixby Common

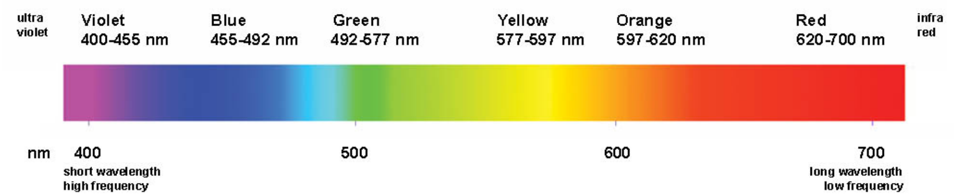
Chem 4A Scholars Worksheet 4

Quantization, Photoelectric Effect and Bohr Atom

Useful equations:

$$E_P = \frac{hc}{\lambda} \quad \nu = \frac{1}{\lambda} \quad E_P = E_K + \phi \quad E_K = \frac{1}{2} m v^2 \quad \nu = -R\infty \frac{Z^2}{n^2} \quad c = 3.00\times10^8\ m\ s^{-1}$$

$$h = 6.63\times10^{-34}\ J\ s \quad R\infty = 10973731.6 m^{-1} \quad 1eV = 1.602\times10^{-19}\ J \quad m_e = 9.10\times10^{-31}\ kg$$



Questions:

1. *700nm light was shine on a Calcium surface. Will electrons be ejected? If so, what is the maximum speed of the electron?* $\phi(Ca) = 1.87eV$

$$\phi(Ca) = 1.87eV = 1.87\times1.602\times10^{-19} = 3.00\times10^{-19}\ J$$

$$E_P = \frac{hc}{\lambda} = \frac{6.63\times10^{-34} \times 3.00\times10^8}{7.00\times10^{-7}} = 2.84\times10^{-19} J < \phi(Ca)$$

Electron will not be ejected.

2. *What if the wavelength of the incident light is 400nm?*

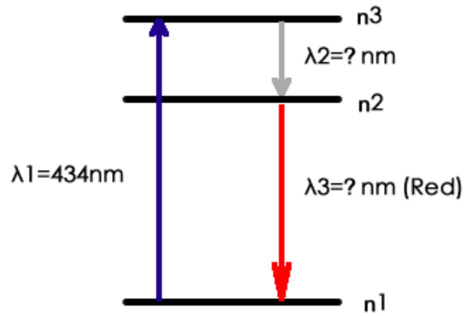
$$E_P = \frac{hc}{\lambda} = \frac{6.63\times10^{-34} \times 3.00\times10^8}{4.00\times10^{-7}} = 4.97\times10^{-19} J > \phi(Ca)$$

Electron will be ejected.

$$E_k = E_p - \phi = 4.97\times10^{-19} - 3.00\times10^{-19} = 1.97\times10^{-19} J$$

$$v = \sqrt{\frac{2\ E_k}{m_e}} = \sqrt{\frac{2\times1.97\times10^{-19}}{9.10\times10^{-31}}} = 6.58\times10^5\ m\ s^{-1}$$

3. *Solve the following problem according the Bohr's model:*



A hydrogen atom was initially at some unknown energy level n1. The hydrogen atom absorbed a photon with wavelength of 434nm, and went to a higher energy state n3. It then went through 2 transitions and emits two photons. The second photon was red. Find the wavelength of the first photon and the second photon was red. Find the energy levels n1, n2, n3, and the wavelength of the photons.

First not that λ1 is with in the Visible spectrum, which means that it belongs to the Balmer series. n1=2.

$$\frac{\mathbf{1}}{\boldsymbol{\lambda_1}} = R\infty(\frac{1}{{n_1}^2} - \frac{1}{{n_3}^2})$$

$$\frac{\mathbf{1}}{\mathbf{434\times10^{-9}}} = \mathbf{10973731.6}\times(\frac{1}{2^2} - \frac{1}{{n_3}^2})$$

$$n_3 = 5$$

$$n_2\ can\ be\ 3\ or\ 4. When\ n_2 = 3, \lambda_3 = 656nm, which\ is\ red.$$

$$\frac{\mathbf{1}}{\boldsymbol{\lambda_2}} = R\infty(\frac{1}{{n_2}^2} - \frac{1}{{n_3}^2})$$

$$\boldsymbol{\lambda_2 = 1282nm}$$

4. *Would you expect a photon with wavenumber of 30000 cm^{-1} to be absorbed by a hydrogen atom at ground state?*

The energy transition of ground state to excited state is

$$\boldsymbol{\nu} = R\infty\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \boldsymbol{8227500m^{-1} = 82275cm^{-1}}$$

$$\boldsymbol{Thus\ the\ photon\ does\ not\ have\ enough\ energy\ to\ excite\ the\ hydrogen\ atom.}$$