Homework 2

Sean Eva

September 2021

1. (a) If the hydrogen begins are the $n = 2$ state , it begins with $E_2 = 13.6(1-\frac{1}{2^2}) = 10.2$eV. In order for the hydrogen to become ionized it needs to have 13.6eV of energy. This means that it needs $13.6-10.2 = 3.4$eV of energy to become ionized.

   (b) Formula: $E = hv = \frac{hc}{\lambda}$ where h is Planck's Constant.

$$\begin{aligned} 3.4eV &= 5.44 * 10^{-19} \\ 5.44 * 10^{-19} &= 6.625 * 10^{-34} v \\ 8.211 * 10^{14} Hz &= v \\ c &= v\lambda \\ 3 * 10^8 &= (8.211 * 10^{14})\lambda \\ 365\text{nm} &= \lambda \end{aligned}$$

2. (a)

$$\begin{aligned} \Delta E &= \frac{hc}{\lambda} \\ \lambda &= \frac{hc}{\Delta E} \\ \frac{1}{\lambda} &= RZ^2(\frac{1}{m^2} - \frac{1}{n^2}) \\ \Delta E &= RhcZ^2(\frac{1}{m^2} - \frac{1}{n^2}) \\ \Delta E &= (1.097 * 10^7)(3.625 * 10^{-34})(3 * 10^8)(\frac{1}{1^2} - \frac{1}{4^2}) \\ \Delta E &= 1.118 * 10^{-18}\text{J} = 6.988\text{eV} \end{aligned}$$

   (b) Since the energy for emission is the same as the energy for absorption the photon would need the same amount of energy of 6.998eV.

3. Energy to ionize a hydrogen atom: 13.6eV. The energy at $n = 3$ is $E_n = 13.6\text{eV}(1 - \frac{1}{n^2}) = 13.6(1 - \frac{1}{9}) = 12.1$eV. Therefore, the photon

would need $13.6 - 12.1 = 1.5\text{eV}$.

$$1.5 * (1.6 * 10^{-19}) = \frac{(3.625 * 10^{-34})(3 * 10^8)}{\lambda}$$
$$453\text{nm} = \lambda$$

4. Rydberg Formula: $\frac{1}{\lambda} = RZ^2(\frac{1}{m^2} - \frac{1}{n^2})$

$$\frac{1}{468.6 * 10^{-9}} = (1.097 * 10^7)(2)^2(\frac{1}{m^2} - \frac{1}{n^2})$$
$$= (\frac{1}{m^2} - \frac{1}{n^2}).$$

   If $m = 3$ and $n = 4$. Then this equality is true. Therefore, this electronic transition is the Paschen α line.

5. The minimum amount of energy to excite the atom would be to move it from the ground state to $n = 2$. The amount of energy to cause this change would be 10.2eV.

6. (a) $5.1\text{eV} = 8.16 * 10^{-19}$

$$8.16 * 10^{-19} - \frac{1}{2}mv^2$$
$$= \frac{1}{2}(9.11 * 10^{-31} * v^2$$
$$1.33 * 10^6 \frac{m}{s} = v.$$

   (b)

$$8.16 * 10^{-19} - \frac{1}{2}mv^2$$
$$= \frac{1}{2}(1.67 * 10^{-27} * v^2$$
$$9.77 * 10^8 \frac{m}{s} = v.$$