06/17/22

Green light has a wavelength of 550 nm. How much energy does 1 mole of green photons contain?

$$E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\,sec)(3\times10^{8}\ m/sec)}{550\times10^{-9}\ m} = 3.61\times10^{-19}\ J/photon$$

$$3.61\times10^{-19}\ \frac{J}{photon} \times \frac{6.02\times10^{23}\ phot}{mol} = 2.17\times10^{5}\ J$$

or 217 kJ

The NIF (National Ignition Facility) is a lab where nuclear fusion is being studied. To make this happen, they direct $1.8\text{x}10^6$ J of laser light (with a wavelength of 351 nm) onto a tiny target to try to start the fusion process. How many photons of light is this?

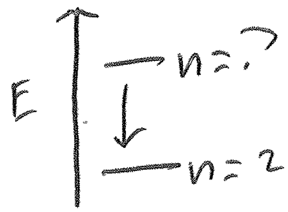
$$E = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\ J\,sec \times 3\times10^{8}\ m/sec}{351\times10^{-9}\ m} = 5.66\times10^{-19}\ \frac{J}{phot}$$

$$1.8\times10^{6}\ J \times \frac{1\ phot}{5.66\times10^{-19}\ J} = 3.18\times10^{24}\ photons$$

All of the energy described above is delivered to the target in 2.4 nanoseconds. Power is defined as energy per unit time and 1 Watt = 1 Joule/second. How many watts of power is a pulse laser light at the NIF? For comparison, the sum total of electricity generation in the US is about 1000 gigawatts.

$$\frac{1.8\times10^{6}\ J}{2.4\times10^{-9}\ sec} = 7.5\times10^{14}\ W \text{ or } 750\ TW$$

The line of light from the hydrogen discharge lamp result from an electron making a transition that ends at the n=2 level. The wavelength of the red line is 656.2 nm, the wavelength of the aqua line is 486.1nm and the wavelength of the blue/purple line is 434.0 nm. Which transition is responsible for each line (i.e. which n level did the electron start from)?



$E_n = -\frac{Rhc}{n^2}$

$E_2 = \frac{-(1.097\times10^7 m^{-1})hc}{2^2}$

$E_2 = -5.45\times10^{-19} J$

$E_{656.2} = \frac{hc}{\lambda} = 3.03\times10^{-19} J$

$E_{486.1} = 4.09\times10^{-19} J$

$E_{434.0} = 4.58\times10^{-19} J$

$\Delta E = E_2 - E_?$

$hc/e\lambda$

$-3.03\times10^{-19} J = -5.45\times10^{-19} J - \frac{-Rhc}{n^2} \rightarrow n=3$ for 656.2 nm

$-4.09\times10^{-19} J = -5.45\times10^{-19} J - \frac{-Rhc}{n^2} \rightarrow n=4$ for 486.1 nm

$-4.58\times10^{-19} J = -5.45\times10^{-19} J - \frac{-Rhc}{n^2} \rightarrow n=5$ for 434.0 nm

If you want to excite an electron from the n=3 level to the n=6 level, you can shine light of the appropriate wavelength/frequency on the sample. What wavelength of light is required to do this?

$E_3 = \frac{-Rhc}{3^2} = -2.42\times10^{-19} J$

$E_6 = \frac{-Rhc}{6^2} = -6.057\times10^{-20} J$

$\Delta E = 1.81\times10^{-19} J$ must be added

$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E} = \frac{(6.626\times10^{-34} J\,sec)(3\times10^8 m/sec)}{1.81\times10^{-19} J}$

$\lambda = 1.098\times10^{-6} m$ or 1098 nm