

06/12/24

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

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ Jsec})(3 \times 10^8 \text{ m/sec})}{550 \times 10^{-9} \text{ m}} = 3.61 \times 10^{-19} \text{ J/photon}$$
$$3.61 \times 10^{-19} \frac{\text{J}}{\text{photon}} \times \frac{6.02 \times 10^{23} \text{ phot}}{\text{mol}} = 2.17 \times 10^5 \text{ J}$$

or 217 kJ

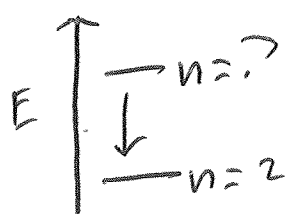
The NIF (National Ignition Facility) is a lab where nuclear fusion is being studied. To make this happen, they direct $1.8 \times 10^6 \text{ J}$ of laser light (with a wavelength of 351 nm) onto a tiny target to try to start the fusion process. How many photons of light is this?

$$E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \text{ Jsec} \times 3 \times 10^8 \text{ m/sec}}{351 \times 10^{-9} \text{ m}} = 5.66 \times 10^{-19} \frac{\text{J}}{\text{phot}}$$
$$1.8 \times 10^6 \text{ J} \times \frac{1 \text{ phot}}{5.66 \times 10^{-19} \text{ J}} = 3.18 \times 10^{24} \text{ photons}$$

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.

$$\frac{1.8 \times 10^6 \text{ J}}{2.4 \times 10^{-9} \text{ sec}} = 7.5 \times 10^{14} \text{ W or } 750 \text{ TW}$$

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 486.1 nm 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)?



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

$$E_2 = \frac{(1.097 \times 10^7 \text{ m}^{-1})hc}{2^2}$$

$$E_2 = -5.45 \times 10^{-19} \text{ J}$$

$$E_{656.2} = \frac{hc}{\lambda} = 3.03 \times 10^{-19} \text{ J}$$

$$E_{486.1} = 4.09 \times 10^{-19} \text{ J}$$

$$E_{434.0} = 4.58 \times 10^{-19} \text{ J}$$

$$\Delta E = E_2 - E_n$$

$$\begin{matrix} \nearrow \\ \nwarrow \end{matrix} \begin{matrix} hc \\ \text{exo} \end{matrix} \quad -3.03 \times 10^{-19} \text{ J} = -5.45 \times 10^{-19} \text{ J} - \frac{Rhc}{n^2} \rightarrow n=3 \text{ for } 656.2 \text{ nm}$$

$$-4.09 \times 10^{-19} \text{ J} = -5.45 \times 10^{-19} \text{ J} - \frac{Rhc}{n^2} \rightarrow n=4 \text{ for } 486.1 \text{ nm}$$

$$-4.58 \times 10^{-19} \text{ J} = -5.45 \times 10^{-19} \text{ J} - \frac{Rhc}{n^2} \rightarrow n=5 \text{ for } 434.0 \text{ nm}$$

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?

$$E_3 = \frac{-Rhc}{3^2} = -2.42 \times 10^{-19} \text{ J}$$

$$E_6 = \frac{-Rhc}{6^2} = -6.057 \times 10^{-20} \text{ J}$$

$$\Delta E = 1.81 \times 10^{-19} \text{ J} \text{ must be added}$$

$$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(3 \times 10^8 \text{ m/s})}{1.81 \times 10^{-19} \text{ J}}$$

$$\lambda = 1.098 \times 10^{-6} \text{ m} \text{ or } 1098 \text{ nm}$$