

## Emission Line Photons

The energy carried by a photon as it moves from energy level  $m$  to energy level  $n$  is given by this formula:

$$E_{phot} = E_m - E_n = 2.17 \times 10^{-11} \times \left( \frac{1}{m^2} - \frac{1}{n^2} \right) \text{erg}$$

When a photon jumps from level 1 to level 4, the energy it carries is:

$$E_{phot} = E_m - E_n = 2.17 \times 10^{-11} \times \left( \frac{1}{1^2} - \frac{1}{4^2} \right) = 2.03 \times 10^{-11} \text{erg}$$

The energy of a photon is also given by the formula:  $E = \frac{hc}{\lambda}$ ,

where  $c$  is the speed of light ( $2.99 \times 10^8$  m/sec),

and  $h$  is Planck's constant ( $6.63 \times 10^{-27}$  erg sec),

and  $\lambda$  is the wavelength of light.

The wavelength of light whose photons have energy  $E$ , is therefore:

$$\lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-17} \text{ erg sec} \times \frac{2.99 \times 10^8 \text{ m}}{\text{sec}}}{E} = \frac{1.98 \times 10^{-8} \text{ erg m}}{E}$$

(use the absolute value)

For our photon above with  $E = 2.03 \times 10^{-11}$  erg, this wavelength would be:

$$\lambda = \frac{hc}{E} = \frac{1.98 \times 10^{-8} \text{ erg m}}{2.03 \times 10^{-11} \text{ erg}} = 9.74 \times 10^{-8} \text{ m} \times \frac{10^9 \text{ nm}}{1 \text{ m}} = 97.4 \text{ nm}$$

**Table of energy level changes and wavelengths of the associated photons**

|                       |                         |                         |                         |                         |
|-----------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| From level            | 6                       | 5                       | 3                       | 2                       |
| To level              | 5                       | 3                       | 2                       | 1                       |
| E (in ergs)           | $-2.65 \times 10^{-13}$ | $-1.54 \times 10^{-12}$ | $-3.01 \times 10^{-12}$ | $-1.63 \times 10^{-11}$ |
| $\lambda$ (in meters) | $7.47 \times 10^{-6}$   | $1.28 \times 10^{-6}$   | $6.58 \times 10^{-7}$   | $1.22 \times 10^{-7}$   |
| $\lambda$ (in nm)     | 7470                    | 1280                    | 658                     | 122                     |
| Part of spectrum      | IR                      | IR                      | Visible red             | UV                      |