

Atomic Spectroscopy

Planck's constant: $h := 6.62608 \cdot 10^{-34} \cdot \text{joule} \cdot \text{sec}$ Speed of light: $c := 2.9979 \cdot 10^8 \cdot \frac{\text{m}}{\text{sec}}$

Conversion factors: $\text{nm} := 10^{-9} \cdot \text{m}$ $\text{pm} := 10^{-12} \cdot \text{m}$ $\text{aJ} := 10^{-18} \cdot \text{joule}$

Energy of a photon: $E_{\text{photon}} = h\nu = \frac{hc}{\lambda}$

Energy of the hydrogen atom: where n is a quantum number and can have integer values. $E_{\text{atom}} = \frac{-2.178 \cdot \text{aJ}}{n^2}$

Emission Spectroscopy

In emission spectroscopy a photon is created as the electron undergoes a transition from a higher to a lower energy state. Energy conservation requires

$$E_{\text{atom}}^{\text{initial}} = E_{\text{atom}}^{\text{final}} + E_{\text{photon}}$$

Example: Calculate the frequency, wavelength, and energy of the photon emitted when an electron undergoes a transition from the $n=2$ to the $n=1$ state.

$$n_i := 2 \quad n_f := 1 \quad \nu := \frac{-2.178 \cdot \text{aJ}}{n_i^2} = \frac{-2.178 \cdot \text{aJ}}{n_f^2} + h \cdot \nu \quad \left| \begin{array}{l} \text{solve, } \nu \\ \text{float, 4} \end{array} \right. \rightarrow \frac{.2465\text{e}16}{\text{sec}}$$

Calculate the wavelength of the photon: $\lambda := \frac{c}{\nu} \quad \lambda = 121.619 \text{ nm}$

Calculate the energy of the photon: $h \cdot \nu = 1.633 \text{ aJ}$

Absorption Spectroscopy

In absorption spectroscopy a photon is absorbed and an electron is promoted to a higher energy level. Energy conservation requires

$$E_{\text{atom}}^{\text{initial}} + E_{\text{photon}} = E_{\text{atom}}^{\text{final}}$$

Example: Calculate the frequency, wavelength, and energy of the photon required to promote the electron from the $n=1$ to the $n=3$ level.

$$\nu := \nu \quad n_i := 1 \quad n_f := 3 \quad \nu := \frac{-2.178 \cdot \text{aJ}}{n_i^2} + h \cdot \nu = \frac{-2.178 \cdot \text{aJ}}{n_f^2} \quad \left| \begin{array}{l} \text{solve, } \nu \\ \text{float, 4} \end{array} \right. \rightarrow \frac{.2922\text{e}16}{\text{sec}}$$

Calculate the wavelength of the photon: $\lambda := \frac{c}{\nu} \quad \lambda = 102.598 \text{ nm}$

Calculate the energy of the photon: $h \cdot \nu = 1.936 \text{ aJ}$