Chapter 12 Quantum Chemistry

Must learn some Physics to understand Chemistry

Understand Periodic Table and Bonding between the elements

\[ \lambda \nu = c \]

\( \nu \) The frequency in sec\(^{-1} \) or Hz

\( \lambda \) The wave length in meters

WUSB broadcasts on 90.1 MHz.

What is the wavelength?

Don't use your calculator.

A ~ 3000 m
B ~ 300 m
C ~ 30 m
D ~ 3 m
E ~ 30 cm
F ~ 3 cm
G ~ 300 mm
H ~ 30 mm

What is the frequency of blue green light (500 nm or 5000 Å)?

Don't use your calculator.

A \( \approx 6 \times 10^{19} \) Hz
B \( \approx 6 \times 10^{18} \) Hz
C \( \approx 6 \times 10^{17} \) Hz
D \( \approx 6 \times 10^{16} \) Hz
E \( \approx 6 \times 10^{15} \) Hz
F \( \approx 6 \times 10^{14} \) Hz
G \( \approx 6 \times 10^{13} \) Hz
H \( \approx 6 \times 10^{12} \) Hz
The electromagnetic spectrum, showing its various regions and the wavelengths and frequencies associated with each.

A bright light is more intense and has greater amplitude than a dim light. The two waves shown here have the same wavelength, but different amplitudes. Amplitude is represented by the height of the wave at its crest.

\[ \lambda \nu = c \]

\( \lambda \) The wavelength in meters
\( \nu \) The frequency in sec\(^{-1}\) or Hz
\( c \) Speed of light 3.00 x 10\(^8\) m/sec

\[ \lambda = \frac{c}{\nu} \]
\[ \nu = \frac{c}{\lambda} \]

**Red Light 700 nm**

\[ \nu = \frac{3.00 \times 10^8 \text{ m/sec}}{700 \times 10^{-9} \text{ m}} = 4.28 \times 10^{14} \text{ sec}^{-1} \]

\[ \nu = \frac{3.00 \times 10^8 \text{ m/sec}}{400 \times 10^{-9} \text{ m}} = 7.5 \times 10^{14} \text{ sec}^{-1} \]

Red photon (700 nm)

\[ E = \frac{6.62 \times 10^{-34} \text{ J sec}}{4.28 \times 10^{14} \text{ sec}^{-1}} \]
\[ E = 2.28 \times 10^{-19} \text{ J} \]

**Violet Light 400 nm**

\[ \nu = \frac{3.00 \times 10^8 \text{ m/sec}}{700 \times 10^{-9} \text{ m}} = 4.28 \times 10^{14} \text{ sec}^{-1} \]

\[ \nu = \frac{3.00 \times 10^8 \text{ m/sec}}{400 \times 10^{-9} \text{ m}} = 7.5 \times 10^{14} \text{ sec}^{-1} \]

Violet photon (400 nm)

\[ E = \frac{6.62 \times 10^{-34} \text{ J sec}}{7.5 \times 10^{14} \text{ sec}^{-1}} \]
\[ E = 4.96 \times 10^{-19} \text{ J} \]

Energy of the photon in joules

\[ E_{\text{photon}} = h \nu_{\text{photon}} \]

\( h \) Planck’s constant 6.62 x 10\(^{-34}\) J sec
\( \nu \) The frequency in sec\(^{-1}\) or Hz
How about a mole of photons?

\[ E = 2.28 \times 10^{-19} \text{ J} \quad \text{red photon (700 nm)} \]
\[ E_{\text{mole}} = 2.28 \times 10^{-19} \text{ J} \times 6.02 \times 10^{23} = 171,000 \text{ J/mol} \]

How strong is a bond?

A typical C-C bond in a hydrocarbon is 345 kJ

\[ E = 4.96 \times 10^{-19} \text{ J} \quad \text{violet photon (400 nm)} \]
\[ E_{\text{mole}} = 4.96 \times 10^{-20} \text{ J} \times 6.02 \times 10^{23} = 299,000 \text{ J/mol} \]

Energy of the photon in joules

\[ E_{\text{photon}} = h\nu_{\text{photon}} \]

- \( h \): Planck’s constant \( 6.62 \times 10^{-34} \text{ J sec} \)
- \( \nu \): The frequency in sec\(^{-1}\) or Hz

Variation in the maximum kinetic energy of electrons ejected from two different metal surfaces (a and b) by light of various frequencies.

\[ E_{\text{K.E.}} = h\nu - E_{\text{bianding}} \]

The electromagnetic spectrum, showing its various regions and the wavelengths and frequencies associated with each.
Kinetic energy of the ejected electron

\[ E_{K.E.} = h\nu_{\text{photon}} - h\nu_0 \]

The energy of the incoming photon

Some threshold energy characteristic of the metal.

The threshold is called the “work function” of a metal. It represents the chemical binding energy of the electron, \( E_{\text{binding}} \).

Potassium has a threshold energy or work function of \( 3.7 \times 10^{-19} \) J

Will a 700 nm red photon eject an electron?
Will a 400 nm violet photon eject an electron?

\[ E_{K.E.} = h\nu_{\text{photon}} - h\nu_0 \]

E = 2.28 \times 10^{-19} \text{ J} \quad \text{No} \quad \text{red photon (700 nm)}

E = 4.96 \times 10^{-19} \text{ J} \quad \text{Yes} \quad \text{violet photon (400 nm)}

3.7 \times 10^{-19} \text{ J} \times 6.02 \times 10^{23} = 223,000 \text{ J} / \text{mol}

Potassium has a threshold energy or work function of \( 3.7 \times 10^{-19} \) J

\[ E_{K.E.} = h\nu_{\text{photon}} - h\nu_0 \]

\[ E_{K.E.} = 4.96 \times 10^{-19} \text{ J} - 3.7 \times 10^{-19} \text{ J} = \]

\[ E_{K.E.} = 1.3 \times 10^{-19} \text{ J} \]

E = 4.96 \times 10^{-19} \text{ J} \quad \text{Yes} \quad \text{violet photon (400 nm)}