Class #12

Light: 
The Wave Particle Duality

CHEM 107 
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Waves

• Characterized by 
  Wavelength, Frequency, 
  Amplitude, Speed
Waves

\[ \lambda \]

Wavelength (\( \lambda \))

Frequency (\( \nu \))

\( \nu \) Increases \( \lambda \) Increases
Waves

Amplitude = $A$
here $y = A \sin(x)$

Interference

In Phase: Constructive Interference
Interference

Out of Phase: Destructive Interference

Light as a Wave

- Many wave-like properties: Interference & Diffraction
- Until about 1900 the wave model of light was fully accepted.
Light as a Wave

- Wavelength, frequency, speed related by:
  \[ c = \lambda \nu \]
- \( c \) fixed (3 x 10^8 m/s)
- \( \lambda \) (or \( \nu \)) specifies color of the light
- NOT related to brightness

Light as a Particle

- In the early 20th century, several discoveries led to a particle model of light.
- Photons: “particles” of light
- Energy of a photon:
  \[ E = h \nu \]
  \( h \) = “Planck’s Constant”
  = 6.626 x 10^{-34} J s
Photon Energy

- A laser emits red light with wavelength of 633 nm (1 nm = 10\(^{-9}\) m)
- What is the energy of a photon at this wavelength?
- A particular laser has an output of 1 mW (10\(^{-3}\) J/s). How many photons are emitted per second?

Electromagnetic Spectrum

![Image of the electromagnetic spectrum showing the visible spectrum, energy, and wavelength increases.](image-url)
Photoelectric Effect

- Shine light on metal
- See electrons emitted
- Detect # of electrons & kinetic energies.

**Equation:**

\[ n - n_0 = h \nu \]

\[ n_0 \]

\[ n > n_0 \]

**Diagrams:**

- Number of electrons emitted vs. frequency
- Kinetic energy vs. frequency

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Photoelectric Effect

• Experimental results NOT consistent with “wave model” of light.
• Postulate of photons (“particle model” of light) allows explanation. (Einstein, 1905)

Photoelectric Effect

• Light with $\nu = 1.3 \times 10^{15} \text{ s}^{-1}$ ejects electrons from cesium metal. If the kinetic energy of the electrons is $5.2 \times 10^{-19} \text{ J}$, what is the binding energy of electrons in cesium metal?

HINT: Conservation of Energy!