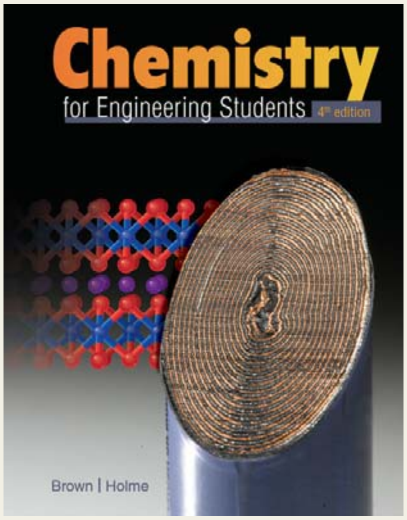

Chapter 6

The Periodic Table and Atomic Structure

Edited by Dr. Katugampola

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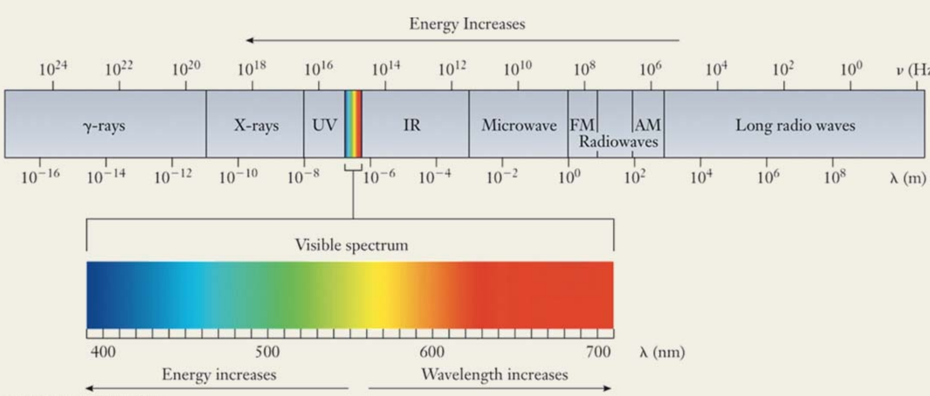
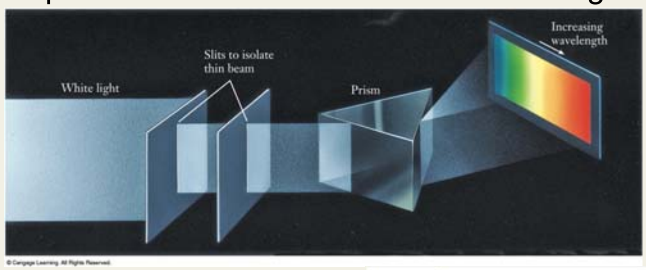
The electromagnetic spectrum

- Visible light is a small portion of the entire electromagnetic spectrum

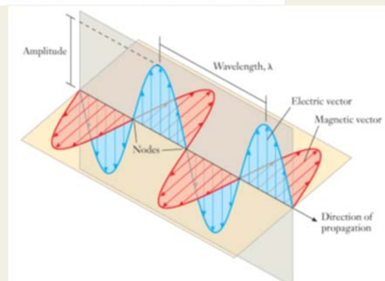


The wave nature of light

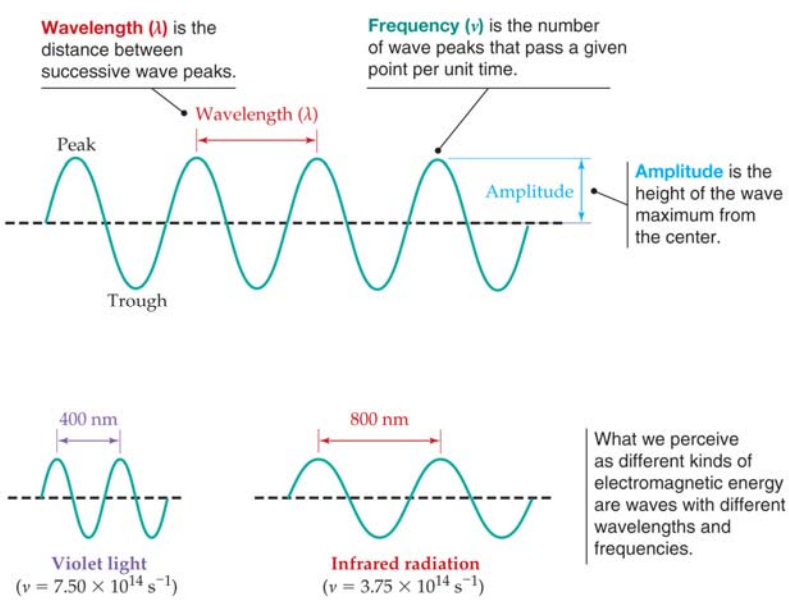
- Light is one form of electromagnetic radiation and separates into its component colors in order of their wavelengths



Light consists oscillating electric and magnetic fields.



The nature of electromagnetic waves



$$\text{Wavelength} \times \text{Frequency} = \text{Speed}$$
$$\lambda\,(\text{m}) \times \nu\,(\text{s}^{-1}) = c\,(\text{m/s})$$

which can be rewritten as:

$$\lambda = \frac{c}{\nu} \quad \text{or} \quad \nu = \frac{c}{\lambda}$$

- *c* is defined to be the rate of travel of all radiant energy in a vacuum and is a constant value—*speed of light.*
- **C = 2.998 × 10^8 m/s**

Example:

The light blue glow given off by mercury streetlamps has a wavelength of 436 nm. What is its frequency in hertz?

Example:

The light blue glow given off by mercury streetlamps has a wavelength of 436 nm. What is its frequency in hertz?

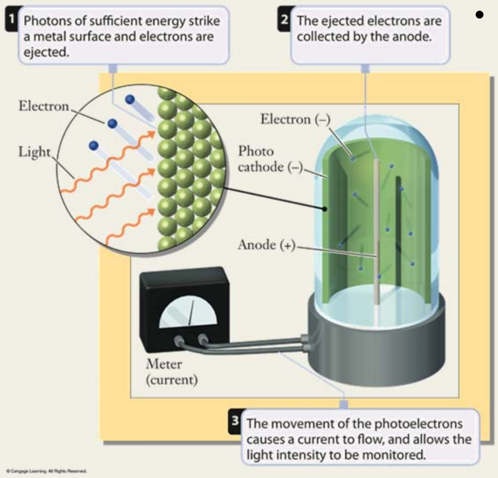
$$\nu = \frac{c}{\lambda} = \frac{\left(2.998 \times 10^{8} \frac{\cancel{\text{m}}}{\text{s}}\right)}{\left(436\ \cancel{\text{nm}}\right)\left(\frac{1\ \cancel{\text{m}}}{1 \times 10^{9}\ \cancel{\text{nm}}}\right)}$$

$$= 6.88 \times 10^{14}\ \text{s}^{-1} = 6.88 \times 10^{14}\ \text{Hz}$$

The Particulate Nature of Light

- Photoelectric effect occurs when light strikes a metal surface and causes electrons to be ejected
  - Energy from the light is transferred to the electrons in the metal
  - With sufficient energy, electrons break free from the metal
  - When more energy is provided, electrons travel faster and have higher kinetic energy as they leave the metal
- Light is described as a collection of packets of energy called photons

The Particulate Nature of Light



- The photoelectric effect is used in photocathodes
  - Light strikes the cathode and ejects electrons
  - Ejected electrons are collected at the anode

- The energy of a photon, *E,* is proportional to its frequency, ν
  - It is inversely proportional to the wavelength, λ

$$E = h\nu = \frac{hc}{\lambda}$$

  - *h* denotes Planck's constant, which is equal to 6.626×10^{-34} J•s

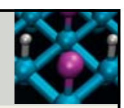
Example Problem

- Chromium can be detected in atomic absorption spectroscopy by monitoring the absorbance of UV light at a wavelength of 357.8 nm. What is the energy of a photon of this light?

$$357.8\ \text{nm} \times \frac{1\ \text{m}}{1{\times}10^{9}\ \text{nm}} = 3.578 \times 10^{-7}\ \text{m}$$

$$E = \frac{hc}{\lambda} = \frac{6.626{\times}10^{-34}\ \text{J s}{\times}2.998{\times}10^{8}\ \text{m s}^{-1}}{3.578{\times}10^{-7}\ \text{m}} = 5.552 \times 10^{-19}\ \text{J}$$

The Particulate Nature of Light (continued)



- Binding energy is the energy holding an electron to a metal
  - Threshold frequency, v_0, is the minimum frequency of light needed to emit an electron
  - For frequencies below the threshold frequency, no electrons are emited
  - For frequencies above the threshold frequency, extra energy is imparted to the electrons as kinetic energy
    - E_{photon} = Binding E + Kinetic E
      - This explains the photoelectric effect

Example Problem

- In a photoelectric experiment, ultraviolet light with a wavelength of 337 nm was directed at the surface of a piece of potassium metal. The kinetic energy of the ejected electrons was measured as 2.30 × 10^{-19} J. What is the electron binding energy for potassium?

$$E_{\text{photon}} = \text{Binding } E + \text{Kinetic } E$$

Photon energy,

$$337 \text{ nm} \times \frac{1 \text{ m}}{10^9 \text{ nm}} = 3.37 \times 10^{-7} \text{ m}$$

$$E_{\text{photon}} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J s})(2.998 \times 10^8 \text{ m s}^{-1})}{3.37 \times 10^{-7} \text{ m}} = 5.89 \times 10^{-19} \text{ J}$$

$$E_{\text{photon}} = \text{Binding } E + \text{Kinetic } E$$

So,

$$\text{Binding } E = E_{\text{photon}} - \text{Kinetic } E$$

$$= 5.89 \times 10^{-19} \text{ J} - 2.30 \times 10^{-19} \text{ J} = 3.59 \times 10^{-19} \text{ J}$$