# Spectrophotometry

# Wave Theory

## Wave

- Repeating disturbance spreading out from a defined origin
- Characterized by wavelength, frequency and amplitude

## Wavelength ($\lambda$)

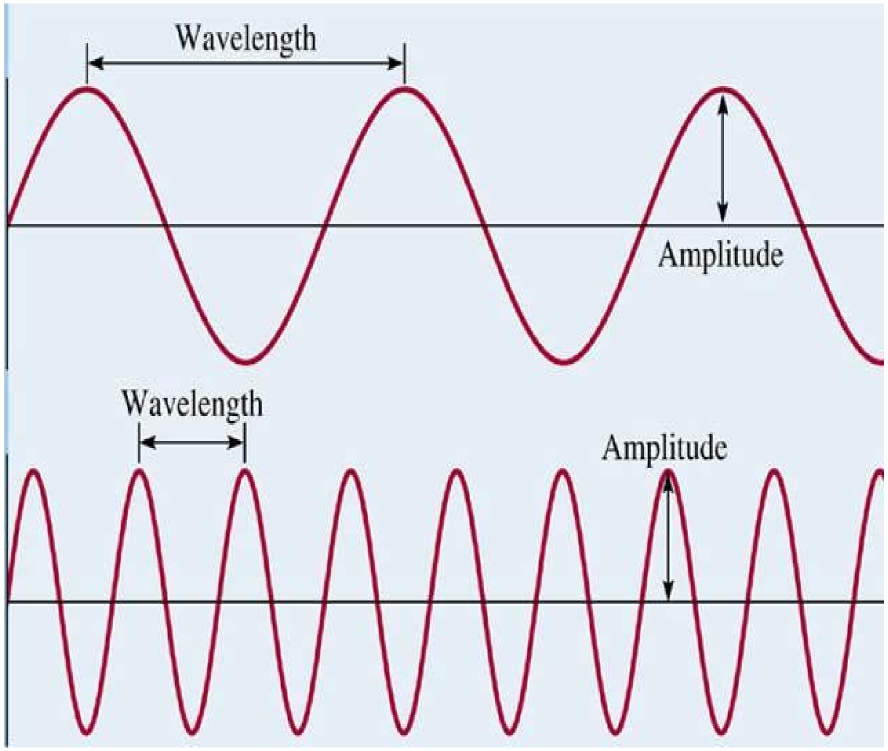
- Distance between identical pts
- Units some form of meters

## Frequency ($\nu$)

- Number of waves that pass through a point in 1 second
- Units of cycles/sec or Hz

## Amplitude

- Height of wave from center pt
- Intensity of wave



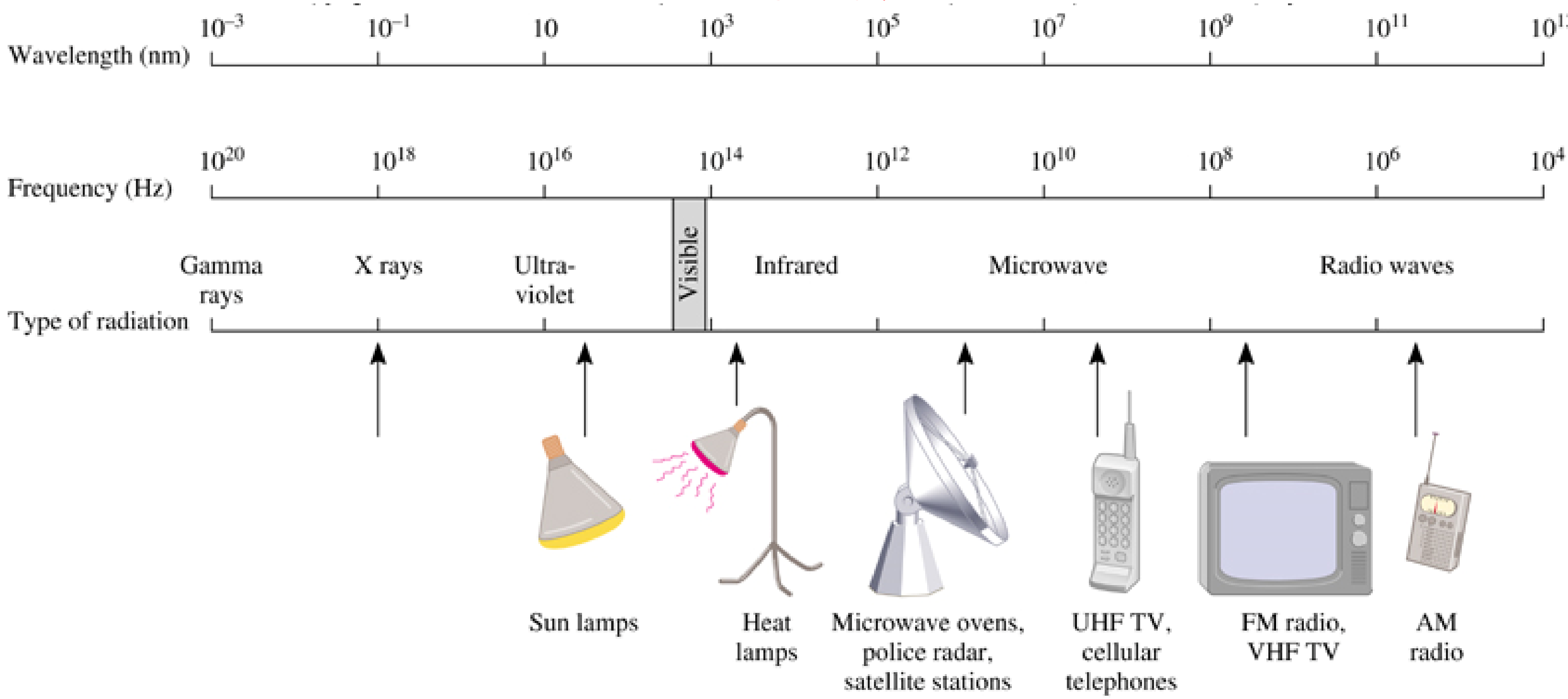
# Electromagnetic Radiation

1. Electromagnetic Radiation travels at the speed of light, c

$$c = 3.00 \times 10^{8}\ m/s$$

2. Frequency & wavelength linked

$$c = \lambda\nu$$



# What is the wavelength of an FM-radiowave with a 94.9 MHz frequency?

$$c = \lambda\nu = 3.00 \times 10^8 \text{ m/s}$$

$$\lambda = c/\nu$$

$$94.9\text{M Hz} = 94.9 \times 10^6 \text{ Hz} = 94.9 \times 10^6/\text{s}$$

$$\lambda = \left[\frac{3.00 \ x10^{8} \ m}{s}\right] x \left[\frac{1 \ s}{94.9 \ x10^{6}}\right] = 3.16 \ m$$

# Energy Level Calculations

All calculations done by comparing energy levels

Electron moves between levels

$E = R_H (1/n_i^2 – 1/n_f^2)$

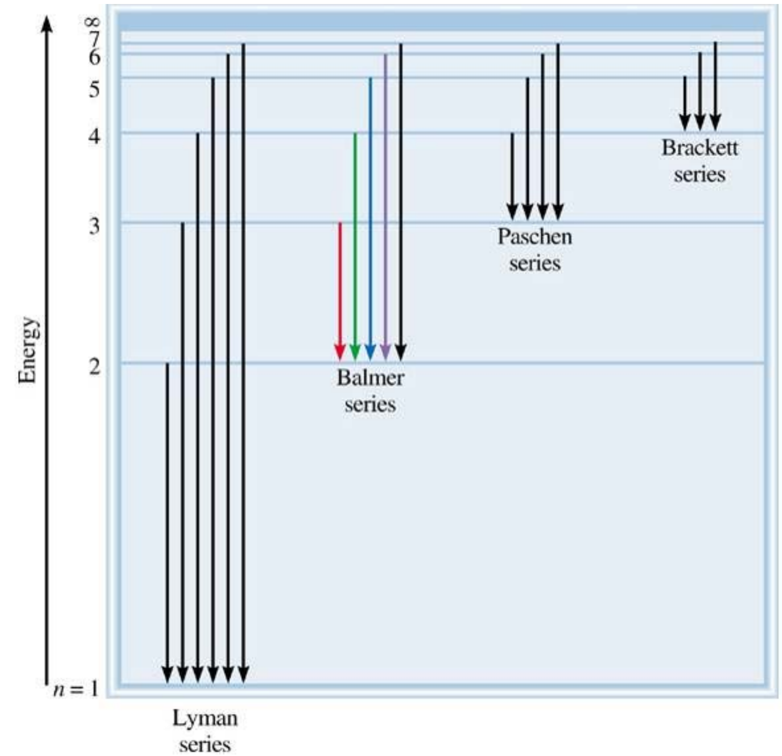
Energy emitted or absorbed

High to low level

energy released (-)

Low to high level

energy absorbed (+)




Ground state: The lowest possible energy level

Excited state: All other levels

Different colors are seen based on the energy released

# Energy Calculations

What is the energy of a radiowave with a frequency of 94.9 MHz?

$$E_{photon} = h\upsilon = \frac{6.626x10^{-34}\,Js}{1} x \frac{94.9x10^{6}}{s} = 6.23x10^{-26}\,J$$

What is the energy per photon and per mole of photons of violet light, with a wavelength of 415 nm?

$$E_{photon} = \frac{hc}{\lambda} = \frac{6.626x10^{-34}\,Js}{1} x \frac{3.00x10^{8}\,m}{s} x \frac{1}{415x10^{-9}\,m} = 4.79x10^{-19}\,J$$

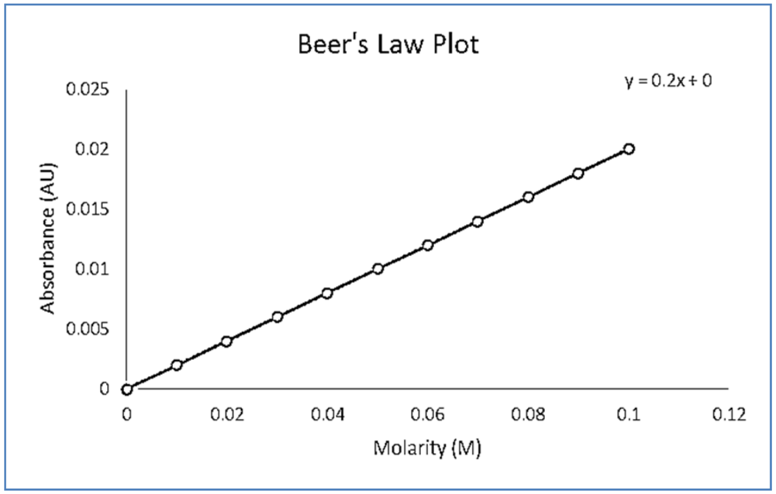
$$E_{mol}\ \frac{4.79x10^{-19}\,J}{photon} x \frac{6.02x10^{23}\,photons}{1mol} = \frac{2.88x10^{5}\,J}{mol}$$

What wavelength has an energy of E = 1.00 x $10^{-20}$J?

$$\lambda = \frac{6.626x10^{-34}\,Js}{1} x \frac{3.00x10^{8}\,m}{s} x \frac{1}{1.00x10^{-20}\,J} = 1.99x10^{-5}\,m$$

# Atomic Absorption and Beer's Law

1. Each atom in a sample absorbs a fixed amount of energy based on how many electrons are excited to a higher state.
2. Colorimeter: Measures absorbance of light in the visible range
3. The absorbance is directly related to the concentration in moles/L.
4. Beer's Law: $A = \varepsilon bc$




A is the absorbance of a solution being measured by the **colorimeter**
$\varepsilon$ is a proportionality constant called the **molar absorptivity**
b is the path length of the **cuvette**, usually 1cm
c is the molarity of the solution

# Recitation Questions

1. A Beer's Law plot for absorbance vs. [$Fe^{2+}$] resulted in the following equation: $y=5367x + 0.0230$.

a. What would be the absorbance for a blank based on this equation?

b. If the absorbance of the $Fe^{2+}$ in the vitamin solution is 0.127AU, calculate the molarity of the $Fe^{2+}$ in the solution using Beer's Law

2. The wavelength of light used in the experiment was approximately 513nm.

a. Calculate the frequency of this light.
b. Calculate the energy in kilojoules of a mole of photons with this wavelength.