Light

- Light
  - How are the wavelength and frequency of light related?

Light

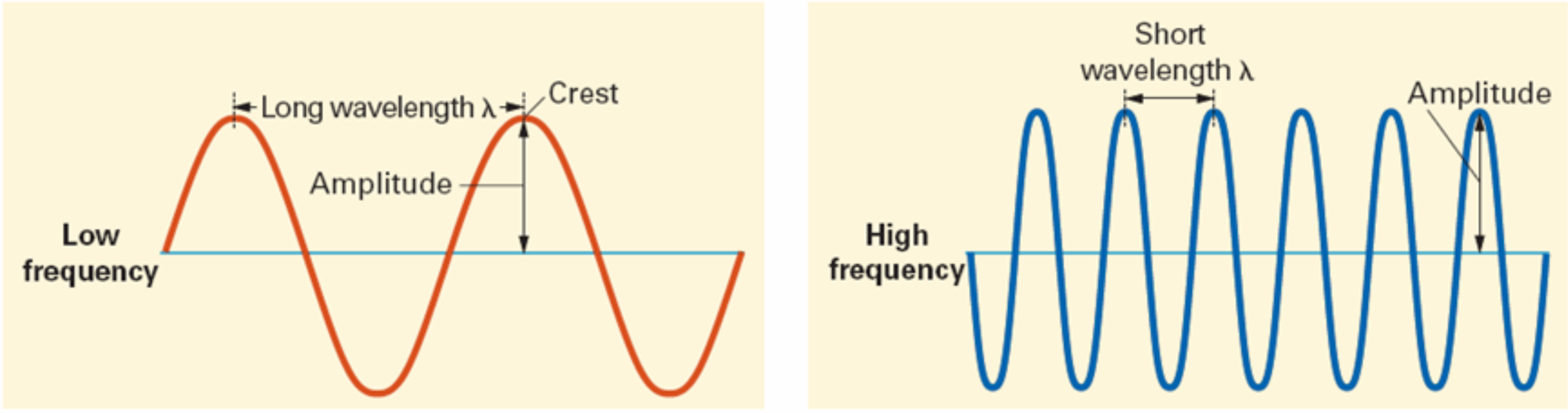
- The **amplitude** of a wave is the wave's height from zero to the crest.
- The **wavelength**, represented by λ (the Greek letter lambda), is the distance between the crests.

Light

- The **frequency**, represented by ν (the Greek letter nu), is the number of wave cycles to pass a given point per unit of time.
- The SI unit of cycles per second is called a **hertz** (Hz).

Light

- **The wavelength and frequency of light are inversely proportional to each other.**



Light

- The product of the frequency and wavelength always equals a constant (*c*), the speed of light.

$$c = \lambda \nu$$

Light

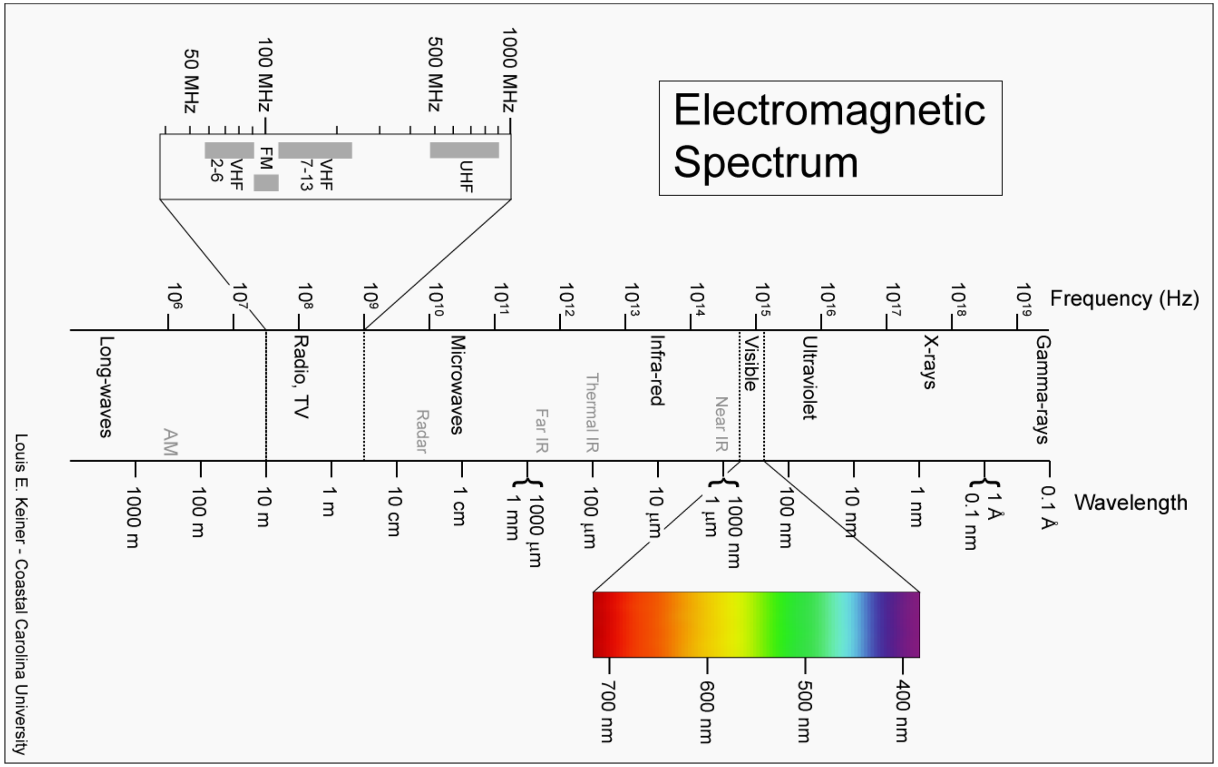
- According to the wave model, light consists of electromagnetic waves.
  - **Electromagnetic radiation** includes radio waves, microwaves, infrared waves, visible light, ultraviolet waves, X-rays, and gamma rays.
  - All electromagnetic waves travel in a vacuum at a speed of 2.998×10^8 m/s.

Light

- Sunlight consists of light with a continuous range of wavelengths and frequencies.
  - When sunlight passes through a prism, the different frequencies separate into a **spectrum** of colors.
  - In the visible spectrum, red light has the longest wavelength and the lowest frequency.

Light

- The electromagnetic spectrum consists of radiation over a broad band of wavelengths.



5.1

Calculating the Wavelength of Light

Calculate the wavelength of the yellow light emitted by the sodium lamp shown above if the frequency of the radiation is 5.10×10^{14} Hz (5.10×10^{14}/s).

15. What is the frequency of radiation with a wavelength of 5.00×10^{-8} m? In what region of the electromagnetic spectrum is this radiation?

Quantization of Energy

Max Planck (1858-1947)
Solved the "ultraviolet catastrophe"

- Planck's hypothesis: *An object can only gain or lose energy by absorbing or emitting radiant energy in QUANTA.*

Quantization of Energy

Energy of radiation is proportional to frequency.

$$E = h \cdot \nu$$

where h = Planck's constant = 6.6262×10^{-34} J•s

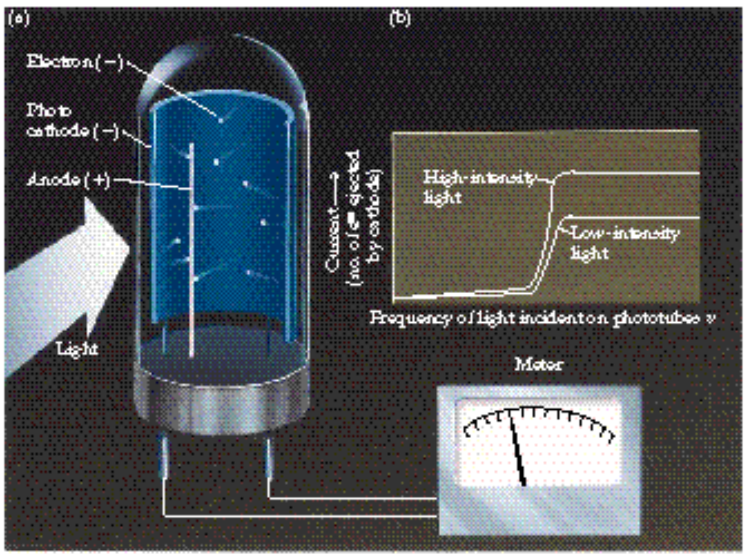
Light with large λ (small ν) has a small E.

Light with a short λ (large ν) has a large E.

Photoelectric Effect

Albert Einstein (1879-1955)

Photoelectric effect demonstrates the particle nature of light. (Kotz, figure 7.6)



No e^- observed until light of a certain minimum E is used.

Number of e^- ejected does NOT depend on frequency, rather it depends on light intensity.

Photoelectric Effect (2)

- Classical theory said that E of ejected electron should increase with increase in light intensity — not observed!

- Experimental observations can be explained if light consists of particles called PHOTONS of discrete energy.

Energy of Radiation

PROBLEM: Calculate the energy of a photon of red light.

λ = 700 nm ν = 4.29×10^{14} sec^{-1}

$E = h \cdot \nu$

$= (6.63 \times 10^{-34}\ J \cdot s)(4.29 \times 10^{14}\ sec^{-1})$

$= 2.85 \times 10^{-19}$ J per photon

Atomic Spectra

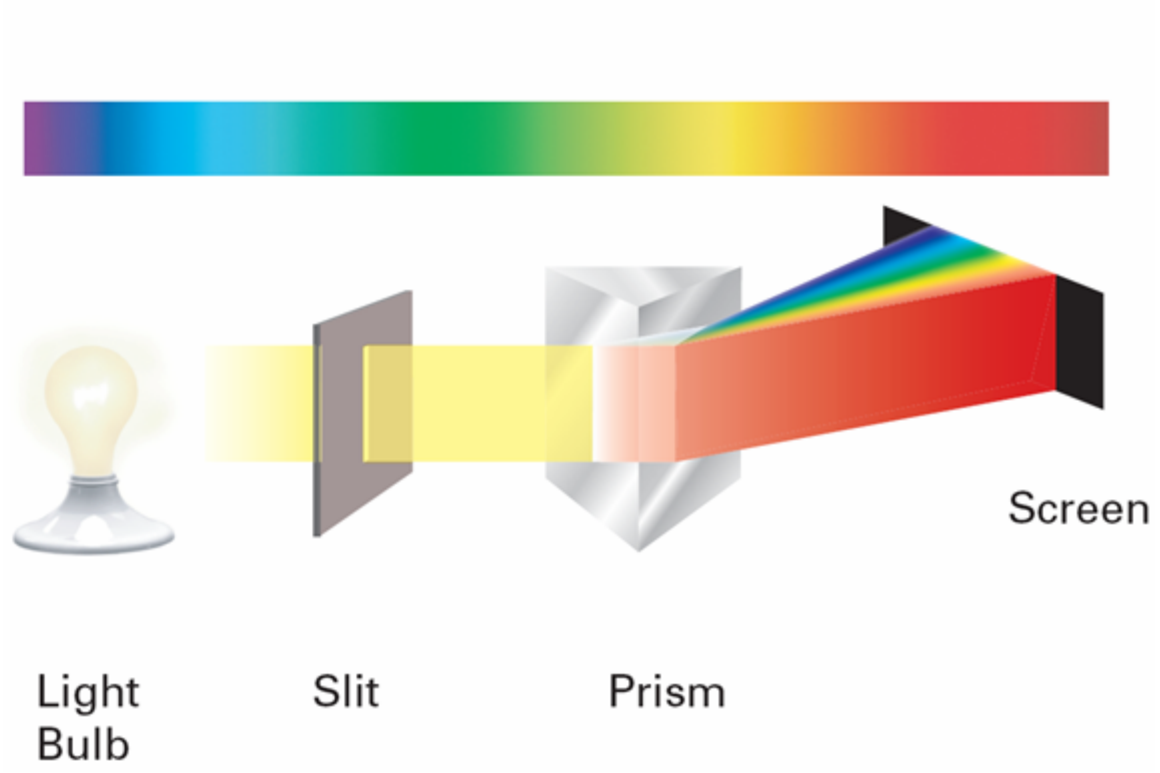
- Atomic Spectra
  - What causes atomic emission spectra?

Atomic Spectra

- When atoms absorb energy, electrons move into higher energy levels. These electrons then lose energy by emitting light when they return to lower energy levels.

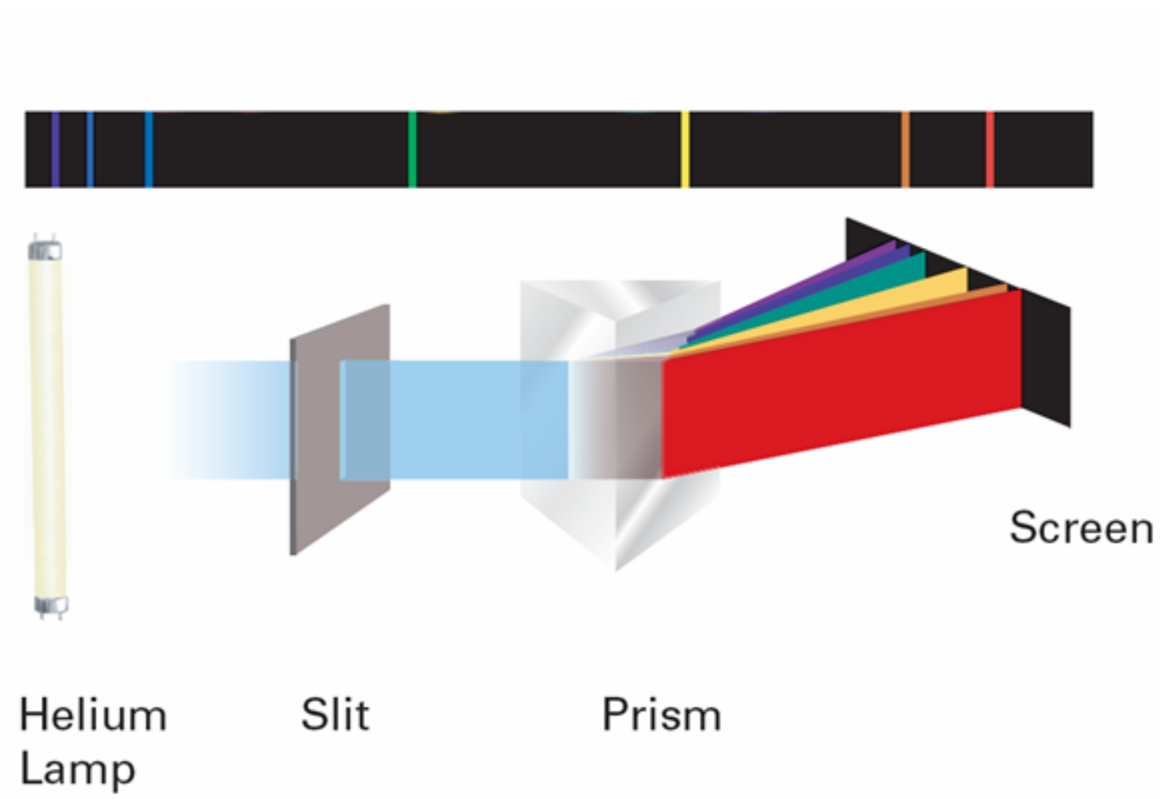
Atomic Spectra

- A prism separates light into the colors it contains. When white light passes through a prism, it produces a rainbow of colors.



Atomic Spectra

- When light from a helium lamp passes through a prism, discrete lines are produced.



Atomic Spectra

- The frequencies of light emitted by an element separate into discrete lines to give the **atomic emission spectrum** of the element.

Mercury

Nitrogen

An Explanation of Atomic Spectra

- An Explanation of Atomic Spectra
  - How are the frequencies of light an atom emits related to changes of electron energies?

An Explanation of Atomic Spectra

- In the Bohr model, the lone electron in the hydrogen atom can have only certain specific energies.
  - When the electron has its lowest possible energy, the atom is in its **ground state.**
  - Excitation of the electron by absorbing energy raises the atom from the ground state to an excited state.
  - A quantum of energy in the form of light is emitted when the electron drops back to a lower energy level.

An Explanation of Atomic Spectra

- The light emitted by an electron moving from a higher to a lower energy level has a frequency directly proportional to the energy change of the electron.