The Electron Cloud

Content Objectives:

I can explain the mathematical relationships between and calculate the energy, frequency, and wavelength of visible light and other forms of electromagnetic radiation.

Criteria for Success:

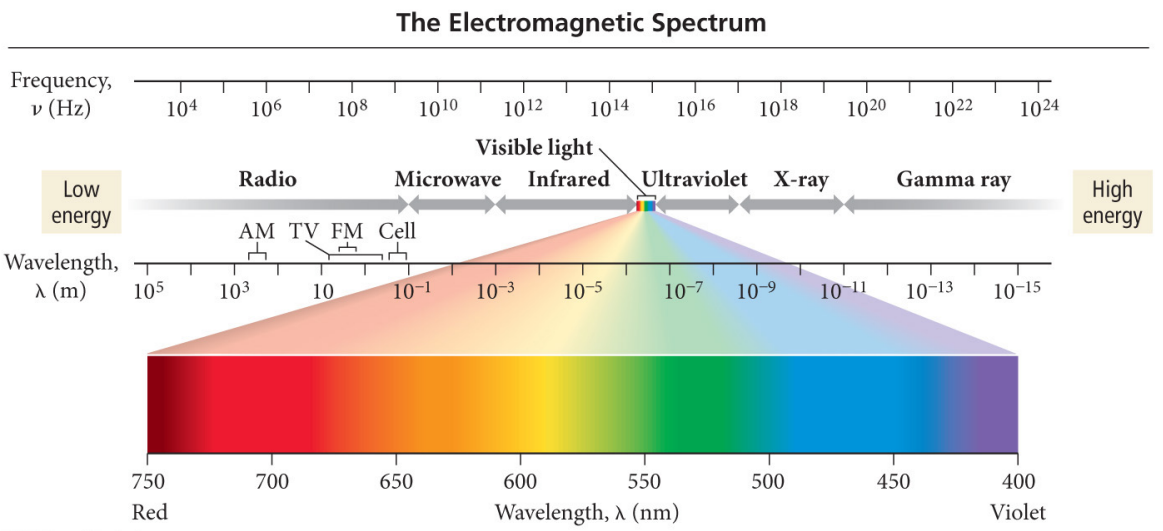
I can describe and interpret the electromagnetic spectrum.
I can calculate wavelength, frequency, speed, and the amount of energy of a photon of light.
I can explain the relationships between energy, frequency, and wavelength.

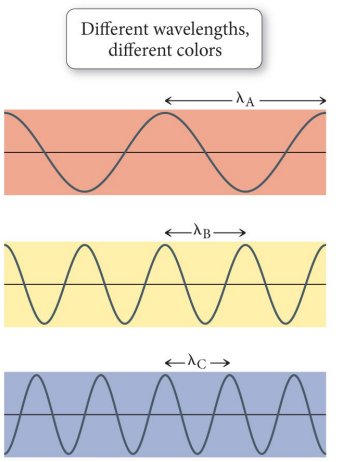
Notes

Development of a New Atomic Model

A. A new atomic model evolved as a result of the investigation into the absorption and emission of _____ by matter.

1. Visible_____ is a kind of_____, which is a form of energy that exhibits both wave-like and particle-like behaviors as it travels through space.





a. Visible light can behave like a _____ characterized by the measurable properties of _____ and _____.

1. _____(λ) is the distance between corresponding points on adjacent waves.

2. _____(ν) is defined as the number of waves that pass a given point in a specific time, usually one second (Often measured in hertz, Hz).

3. The wavelength and frequency for light waves can be related mathematically in the following way:

$$c = \nu \lambda$$

b. Visible light can behave like a stream of particles or_____. A_____ is a particle of electromagnetic radiation having zero mass and carrying a specific amount of energy.

1. The_____ effect is evidence that light behaves as stream as particles.

2. Max Planck suggested and Albert Einstein elaborated on the following formula when describing the relationship between frequency and the_____ of energy of a photon.

$$E_{photon} = h\nu$$

3. A_____ is a specific amount of energy proportional in size to the frequency of the radiation it represents.

4. Recognize that this energy represents the energy of a_____ photon.Be prepared to_____ to energies absorbed or emitted to kilojoules per mole instead of Joules per photon of a single photon.

B. Scientists use this understanding of_____ to also describe the properties of the_____ and their behavior in the electron cloud.

The Electron Cloud

$c = \nu \lambda$

$E_{photon} = h\nu$

$h = 6.626 \times 10^{-34} Js$

$c = 3 \times 10^{8} \frac{m}{s}$

Guided Practice

1. What is the wavelength, in meters, of a photon of light that has a frequency of $2.10 \times 10^{14} Hz$?

2. When sodium is heated, a yellow spectral line whose energy is 3.37×10^{-19} J/photon is produced. What is the frequency of this light?

3. What is the energy of a photon with a wavelength of $8.27 \times 10^{-7} m$?

4. A certain green light has a frequency of 6.26×10^{14} Hz.

a. What is its wavelength?

b. What is the energy of one photon of this light?

c. What is the energy of one mole of photons of this light in kilojoules/mole? Answer in joules.

5. Derive an equation expressing E in terms of h, c, and λ, given the relationships $E = h \nu$ and $c = \nu \lambda$.

The Electron Cloud

$c = \nu \lambda$

$E_{photon} = h\nu$

$h = 6.626 \times 10^{-34}$ Js

$c = 3 \times 10^{8} \frac{m}{s}$

Independent Practice

1. What is the wavelength of a photon that has an energy of 7.37 x 10^{-8}J/photon?

2.70×10^{-18} m

2. What is the energy, in Joules, of a photon of wavelength 1.50×10^{-7}m? What is the energy of one mole of photons in kJ/mole?

$1.33 \times 10^{-18}\ J \times \frac{1\ kJ}{10^{3}\ J} = 1.33 \times 10^{-21} \times 6.02 \times 10^{23} =$

$798 \frac{kJ}{mol}$

3. Cobalt-60 is an artificial radioisotope that is produced in a nuclear reactor for use as a gamma-ray source in the treatment of certain types of cancer. If the wavelength of the gamma radiation from a cobalt-60 source is 1.00×10^{-12} m, calculate the frequency of a photon of this radiation.

$3 \times 10^{20} \frac{1}{s}$

4. Green light has a wavelength of 5.50×10^{2}nm. Calculate the energy of a photon with this wavelength of light.

nm → m

$5.50 \times 10^{2}\ nm \times \frac{10^{-9}\ m}{1\ nm} = 5.5 \times 10^{-7}$ m

3.61×10^{-19} J

5. Label the following as **directly** or **inversely** related? Explain.

A) energy and wavelength

Inversely

B) wavelength and frequency

Inversely

C) frequency and energy

directly