Atoms and electrons: Light and Energy: Student Review Notes

Know this: Light is characterized by a wavelength, λ, and frequency, ν.

These two properties of light are related by the **fundamental relationship** that their product must equal the speed of light.

$$c = \text{speed of light} = 2.998 \times 10^{8}\ \text{m/s} = \lambda\nu$$
$$c = \lambda\nu$$

Also, as wavelength decreases, the energy associated with the light increases—this is **Planck's relationship**

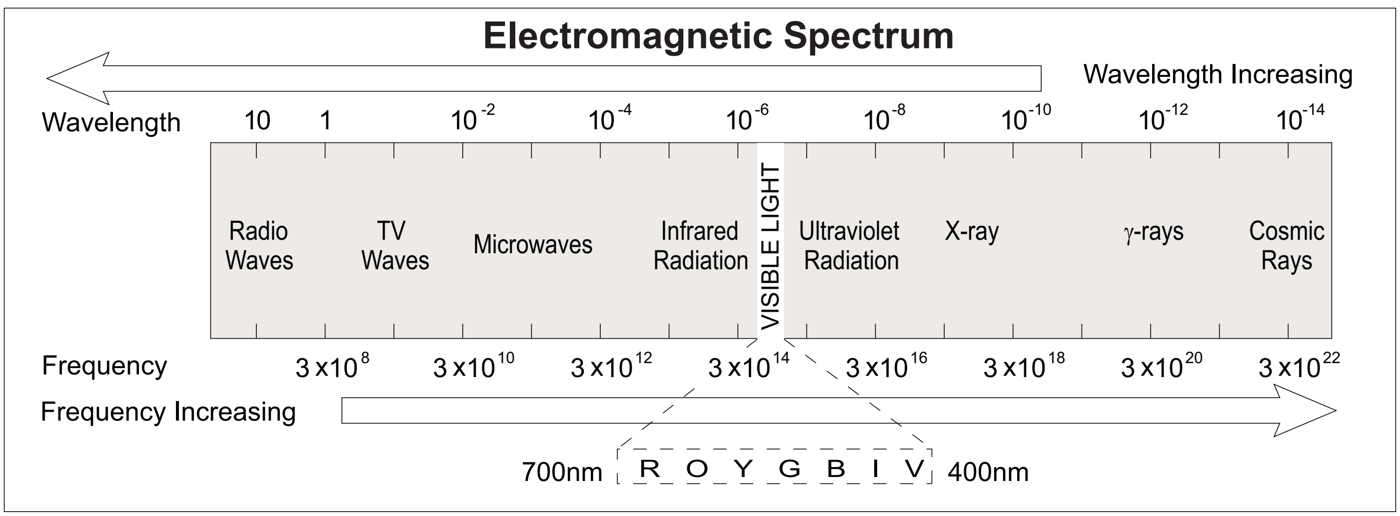
$$E = \text{energy of a photon} = h\nu = hc/\lambda$$
$$h = \text{Planck's Constant} = 6.626 \times 10^{-34}\ \text{Js}$$

Light: Light is energy in the form of radiation or **electromagnetic radiation**. The light that we see is a very small part of the electromagnetic spectrum—it's the visible region shown below.

You need to be familiar with the basic EM spectrum and how different parts of it pertain to the subject of chemistry.

First off, do you know where light comes from? Electromagnetic radiation is generated by the movement of charged particles. Electrons are charged particles and as they transition from one energy state to another, they absorb light or emit light. So, moving electrons create light. When you look at a flame, the different colors of light you see come from the loss of energy by excited electrons. In a flame where are the electrons getting the energy from to move? Combustion is a chemical reaction and energy is emitted as bonds are formed during this reaction.

But, don't just think about electromagnetic radiation as visible light. You can move electrons in a transmitter to create radio waves for example. Take a look at the spectrum below and make sure that you are familiar with the examples of EM radiation and chemistry.



Microwaves: We know about microwave ovens. Why does food heat up in the microwave?
It turns out that this wavelength is just the right size to cause the rotation of water molecules. Water molecules are polar, i.e. they have positive and negative poles and therefore are affected by an oscillating electric field. So, microwaves heat up food by the friction of spinning water molecules (energy in the form of radiation is converted to energy in the form of heat).

Infrared (IR): Here, think of the bonds in a molecule as springs and the IR radiation as something that expands the spring. The spring will then vibrate and if you have exactly the correct frequency, the radiation will resonate with the energy of the spring.
Understand that IR radiation interacts with bonds. By looking at the wavelengths of light absorbed by a chemical, you can get an idea of the bonds with which the chemical is comprised.

Visible Light: Here radiation interacts with individual electrons. The emission spectrum observed from a gas is indicative of allowable electronic transitions. Why do metals reflect? Metals have a sea of mobile electrons and no matter what visible radiation hits the metal, the electron that absorbed it can re-emit the energy back out—so you see your reflection. Why are stop signs red? Because the molecules that make up the sign absorb visible light and re-emit only light with a frequency that we see as red.

Ultraviolet Light: This is more energy than most of the transitions associated with electrons on atoms. UV light therefore often causes ionization or the electron to be blown right off the atom. This is the kind of radiation for which you use sunscreen. You don't want atoms in your skin ionized. Your body will react to these ions and that is where pathologies like cancer can start.