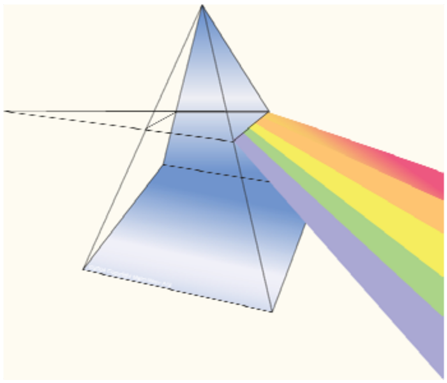
Topic:	THE NATURE OF LIGHT

General topic	Objective ID	Objective
FK_B1_03 **Bohr's atomic theory and atomic emission spectra**	**FK_B1_03_01**	**Given** the wavelength (λ) of a radiation (in nm or Å) and the equivalence between energy units (J and eV) **determine:** • the period (T) of the radiation • the frequency (f) of the radiation • the energy (E) of a photon of this radiation (in J and eV) **using** Planck's constant and the relationships between period, frequency and wavelength

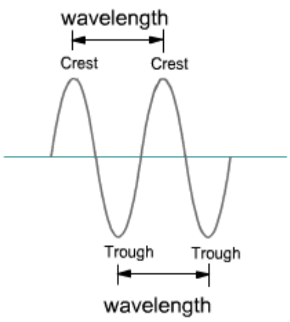
Light as a wave: the wave model of light

Isaac Newton was the first scientist to observe that white light could be dispersed by a .... into the **........................** of colors.



The different colors of light are characterized by their .... and ....

The wavelength (λ, lambda) is the distance between two identical points (crest, trough, node...) in the .... cycles of the ....



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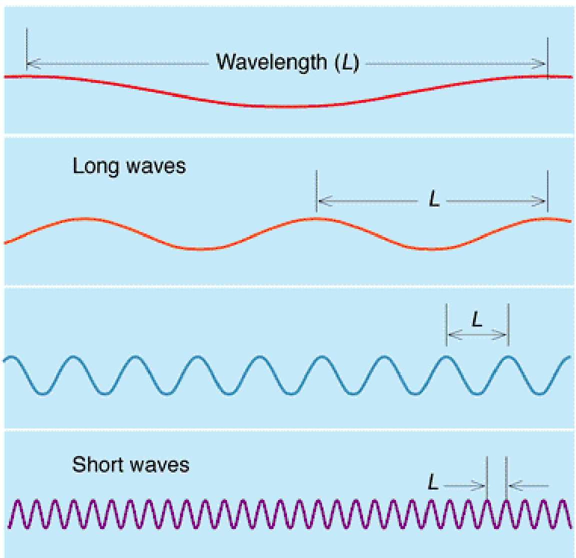
The relation between the color of a monochromatic (one color) ray and the wavelength is as follows: a ray of violet color (one end of the visible spectrum) is .... (the wavelength is smaller) than a ray of ...... light (at the other end of the spectrum).



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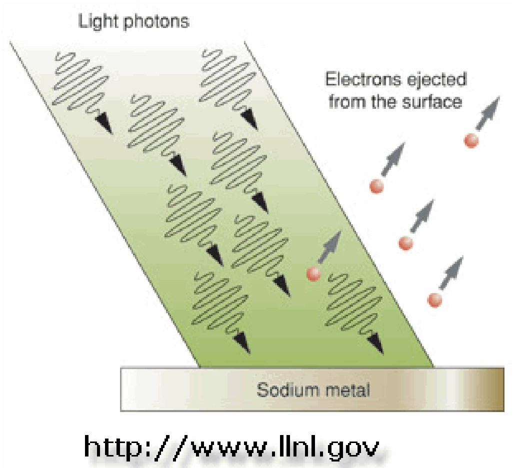
The corpuscular model of light: light as photons

The wave model of light can't explain some experiments, like the .... effect. In the photoelectric effect, when light shines on a metal surface, electrons can be knocked out of the surface. Electrons can be knocked out of the metal by high .... light (................. waves).

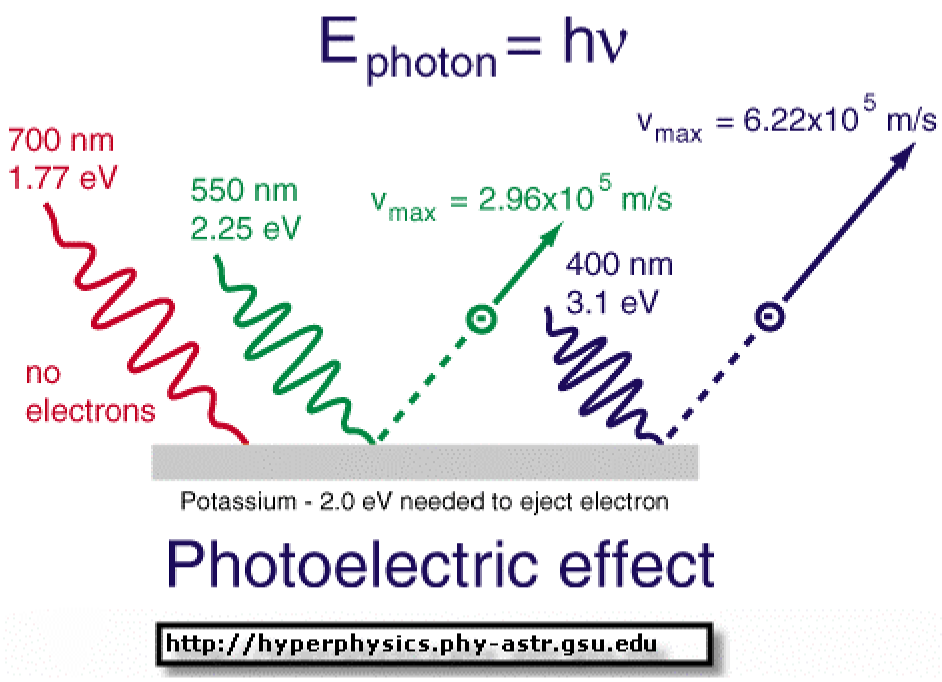


It seems that light consists of wave packets or ....

The energy of the photon depends on the .... of the light, as expressed in the Planck's equation:

$$E = h.f$$

where E is the energy of the photon, f is its frequency and h is the Planck's constant. The value of the constant is $6{,}63.10^{-34}$ J.s



Properties of light

The properties of waves that we are going to study here are:

- wavelength (λ, lambda)
- velocity of propagation (v)
- period (T) and frequency (f)

As mentioned before, ... is the distance between two adjacent similar .... (crest, trough...). That distance can be measured in metres, cm (10^{-2} m), μm (10^{-6} m), nm (nanometre, 10^{-9} m), Å (angstrom, 10^{-10} m).

All electromagnetic waves propagates in vacuum at a velocity of .... metres per second (m/s) (................. of light)

Period is the interval of .... between two adjacent similar points (crest, trough, node...). Period is measured in seconds.

Frequency is the number of times a wave is repeated in a .... Frequency is measured in .... (Hz or cycles/second)

The relation between period and frequency is:

$$f = 1/T \leftrightarrow T = 1/f$$

The relations between velocity of propagation (c), wavelegth (λ), period (T) and frequency (f) are as follows:

$$c = \frac{\lambda}{T} = \lambda . f$$

In order to help remember the previous equations, we can write:

$$\text{c (velocity)} = \frac{\lambda \text{ (space of a cycle)}}{\text{T (time of a cycle)}}$$

$$c = \frac{\lambda}{T\ (=1/f)} = \frac{\lambda}{1/f} = \lambda . f$$

Given the wavelength of a monochromatic light (only one type of light) we could determine the energy carried by a photon of that light in two steps: 1) determine the frequency and 2) determine the energy, using the Planck's equation.

Energy of a photon

Lightwaves carry energy that is determined by the Planck's equation:

$$E = h.f$$

"h" is the Planck's constant and the value is $6{,}63.10^{-34}$ J.s. That equation gives us the energy of each photon of that light.

The energy can be given in J (Joule) or eV (electron-volt). The .... between both units is:

$$\mathbf{1\ eV = 1{,}6.10^{-19}\ J}$$
$$\mathbf{1\ J = 6{,}2.10^{18}\ eV}$$

The relations between the previous variables are:

$$\lambda \xrightarrow{\lambda = c.T} T \xrightarrow{f = 1/T} f \xrightarrow[\text{E=h.f}]{\text{PLANCK}} E$$

$$\lambda \xrightarrow{f = c/\lambda} f \xrightarrow[\text{E=h.f}]{\text{PLANCK}} E$$

Worked example

A monochromatic light has a wavelength of 650 nm. Determine the energy carried by a photon of this light

a) Determination of the period

$$\lambda = c.T \rightarrow T = \frac{\lambda}{c} = \frac{6{,}5.10^{-7}\ m}{3.10^{8}\ m/s} = 2{,}17.10^{-15}\ s$$

b) Determination of the frequency

$$f = \frac{1}{T} = \frac{1}{2{,}17.10^{-15}\ s} = 4{,}62.10^{14}\ Hz$$

c) Determination of energy

$$E = h.f = 6{,}63.10^{-34}\ J.s\ .\ 4{,}62.10^{14}\ s^{-1} = 3{,}06.10^{-19}\ J$$

$$E = 3{,}06.10^{-19}\ J\ \frac{1\ eV}{1{,}6.10^{-19}\ J} = 1{,}91\ eV$$

Problem

Determine the wavelength of a monochromatic light, knowing that the energy of each photon is 3,2 eV

Solution: 385 nm