General Chemistry

202-SN1-RE

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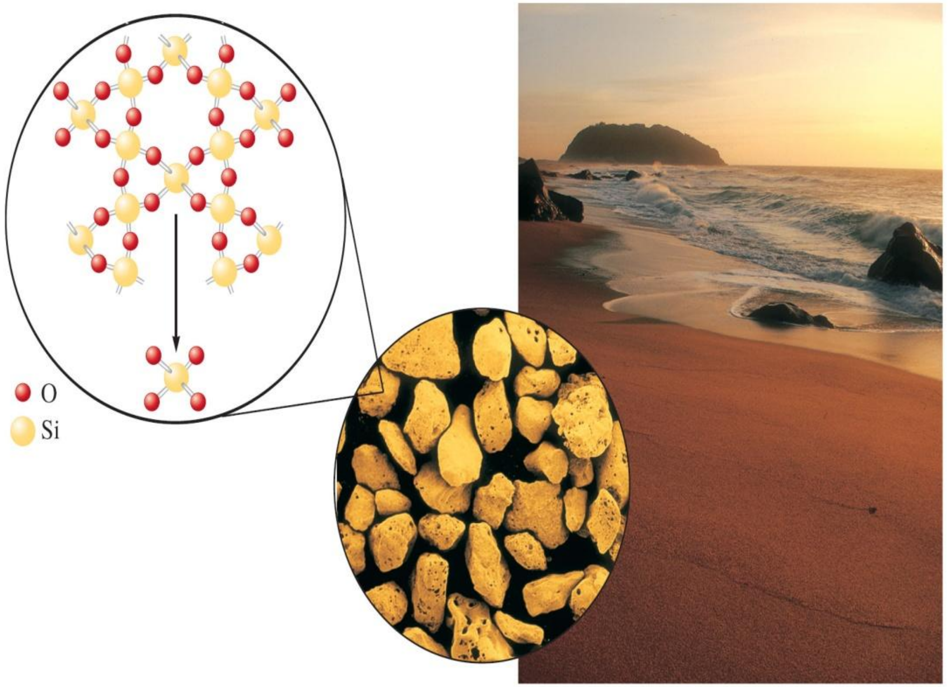
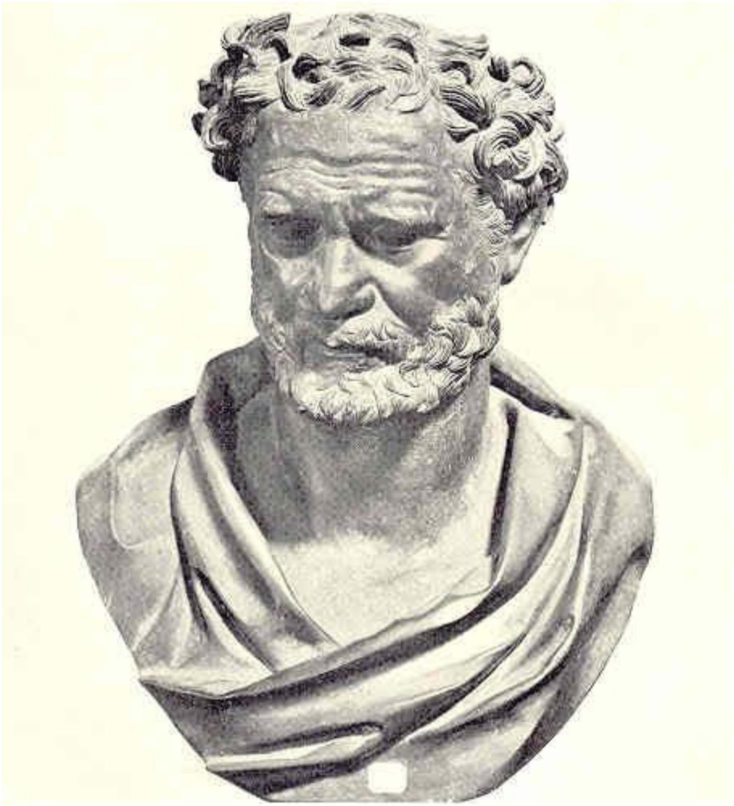
Office: 5th floor

Unit 4a – Early Atomic Structure

Atomic Structure of Matter





The idea of the atom goes back to Democritus and the Ancient Greeks at about 400 B.C.

- Once we came to ‘believe in’ atoms, it was logical to ask: What is the nature of an atom? Does an atom have parts, and if so, what are they?

- Before examining the atomic structure, we must consider the revolution that took place in physics in the first 30 years of the twentieth century. A radical new theory called quantum mechanics was developed to account for the behavior of light and atoms.

- But first, let’s look into electromagnetic radiation.

Electromagnetic Radiation

Watch this video:

Les ondes lumineuses, visibles et invisibles - Lucianne Walkowicz (youtube.com)

Electromagnetic Radiation

- One of the ways that energy travels through space is by electromagnetic radiation.

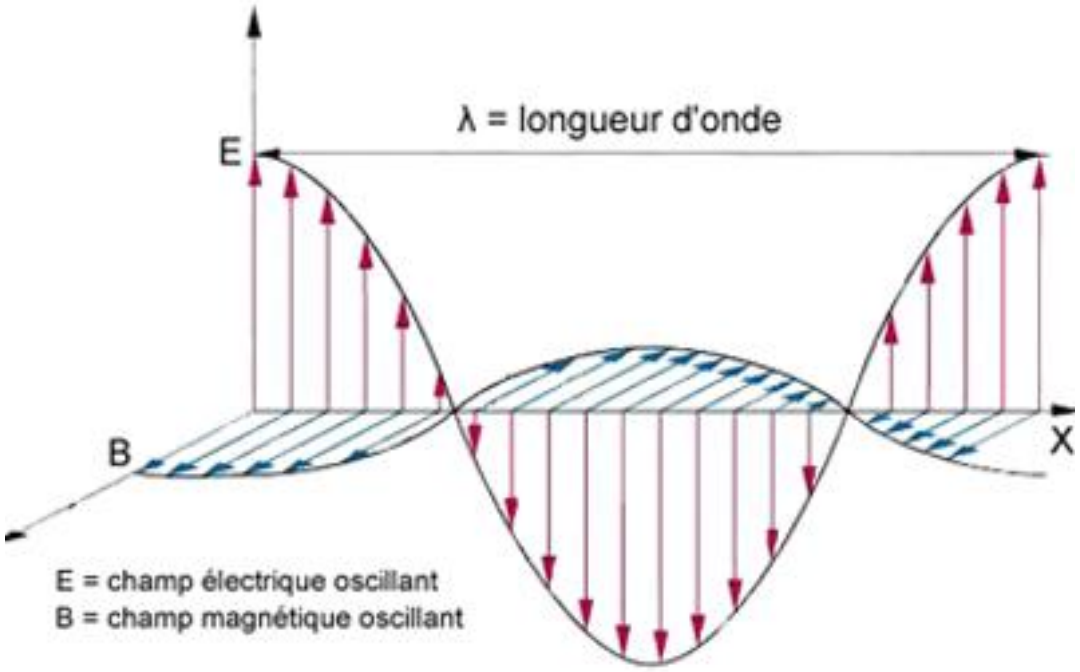
- Examples: visible light, microwaves, x-rays, radiant heat from a fireplace.

- All exhibit same type of wavelike behavior and travel at the speed of light in a vacuum.

Electromagnetic Waves

They are the result of electric charges moving, thus creating a magnetic field and an electric field.

Electromagnetic waves can travel in a vacuum (i.e. no medium required), contrary to sound waves or waves formed in water.



Read:
[Electromagnetic waves | National Oceanic and Atmospheric Administration (noaa.gov)]

Wave Properties of Radiant Energy and the Electromagnetic Spectrum

- Electromagnetic energy (“light”) is characterized by **wavelength**, **frequency**, and **amplitude**.

The Nature of Waves

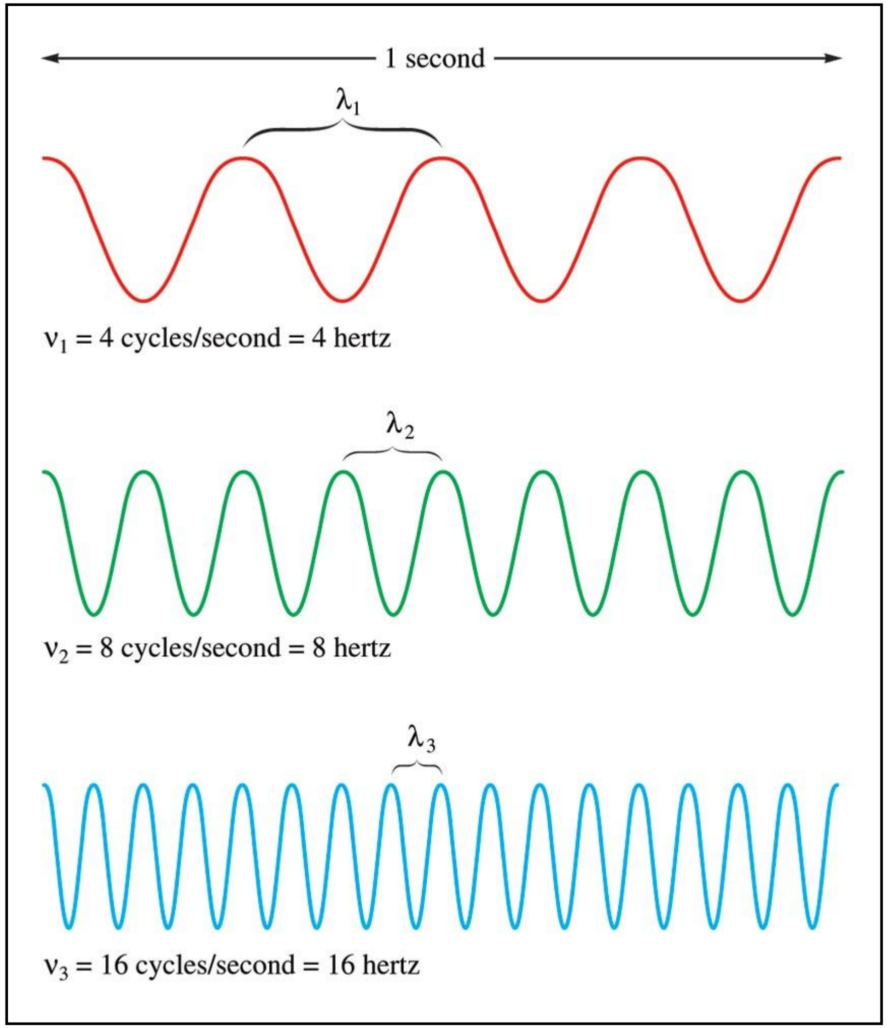
- Three characteristics of electromagnetic radiation:

1. Wavelength (*λ, Greek lambda*) – distance between two peaks or troughs in a wave (m, meters).

2. Frequency (*ν, Greek nu*) – number of waves (cycles) per second that pass a given point in space (Hz, Hertz, or s^{-1}, cycles/second)

3. Speed (*c*) – speed of light (2.998×10^8 m/s)

$$c = \lambda \nu$$



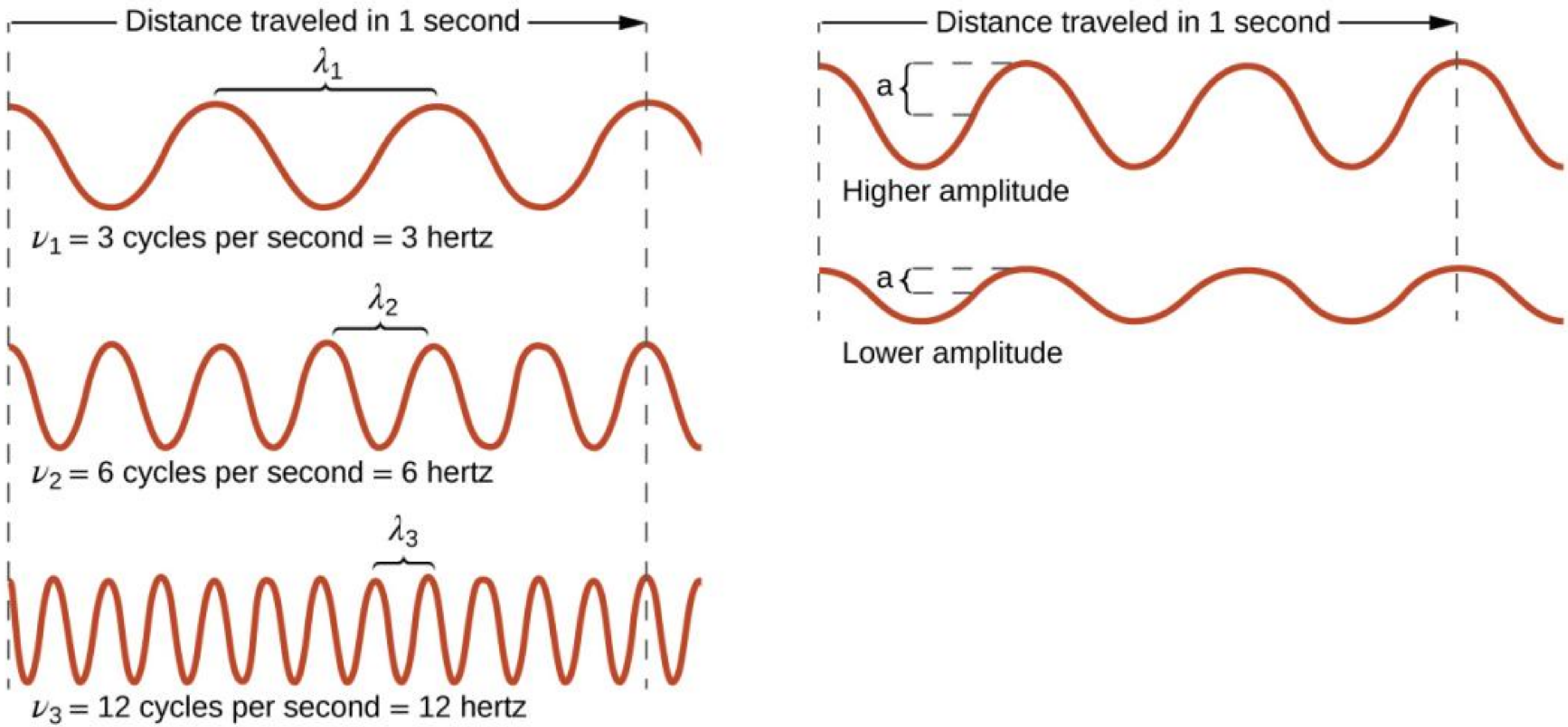
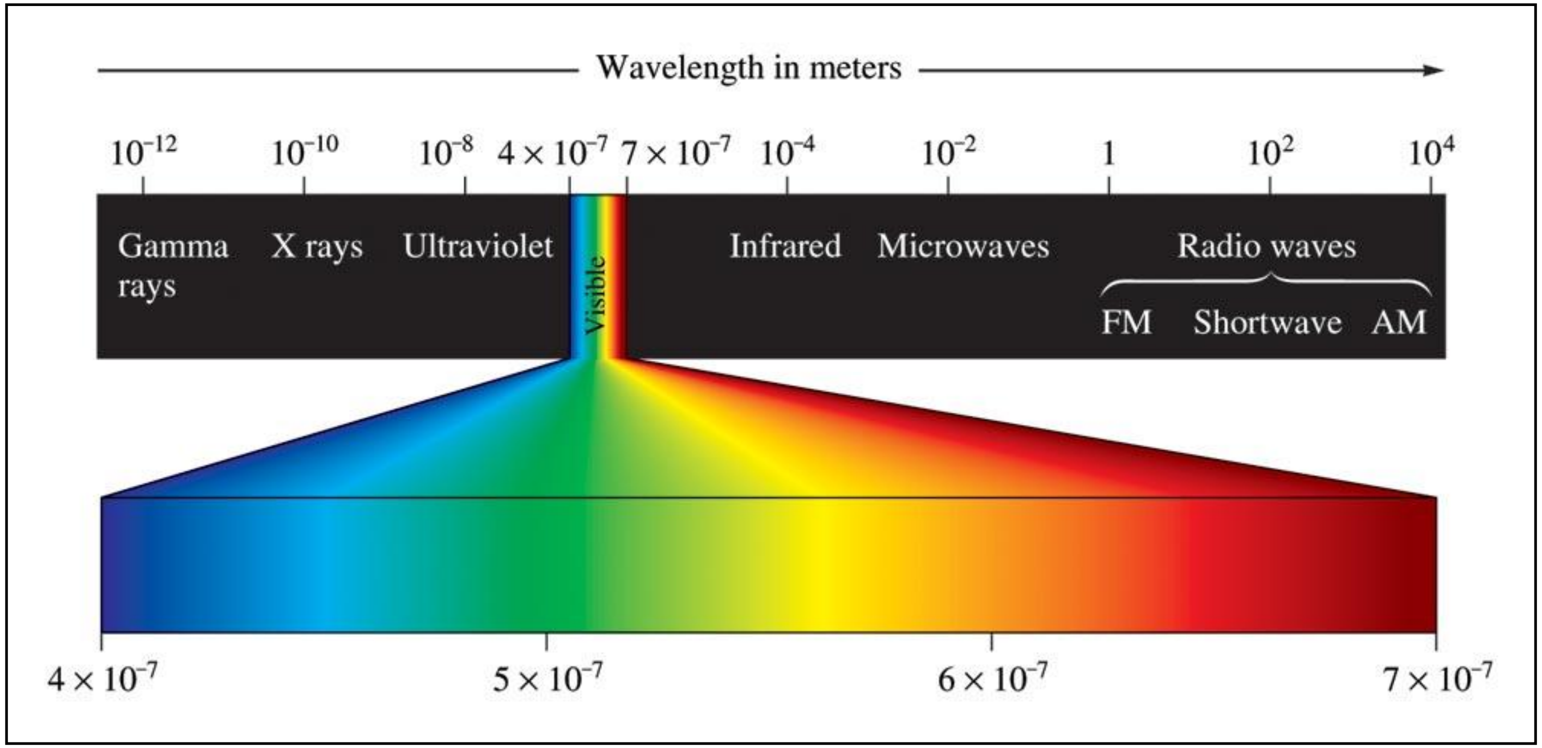


FIGURE 6.2 One-dimensional sinusoidal waves show the relationship among wavelength, frequency, and speed. The wave with the shortest wavelength has the highest frequency. Amplitude is one-half the height of the wave from peak to trough.

Classification of Electromagnetic Radiation



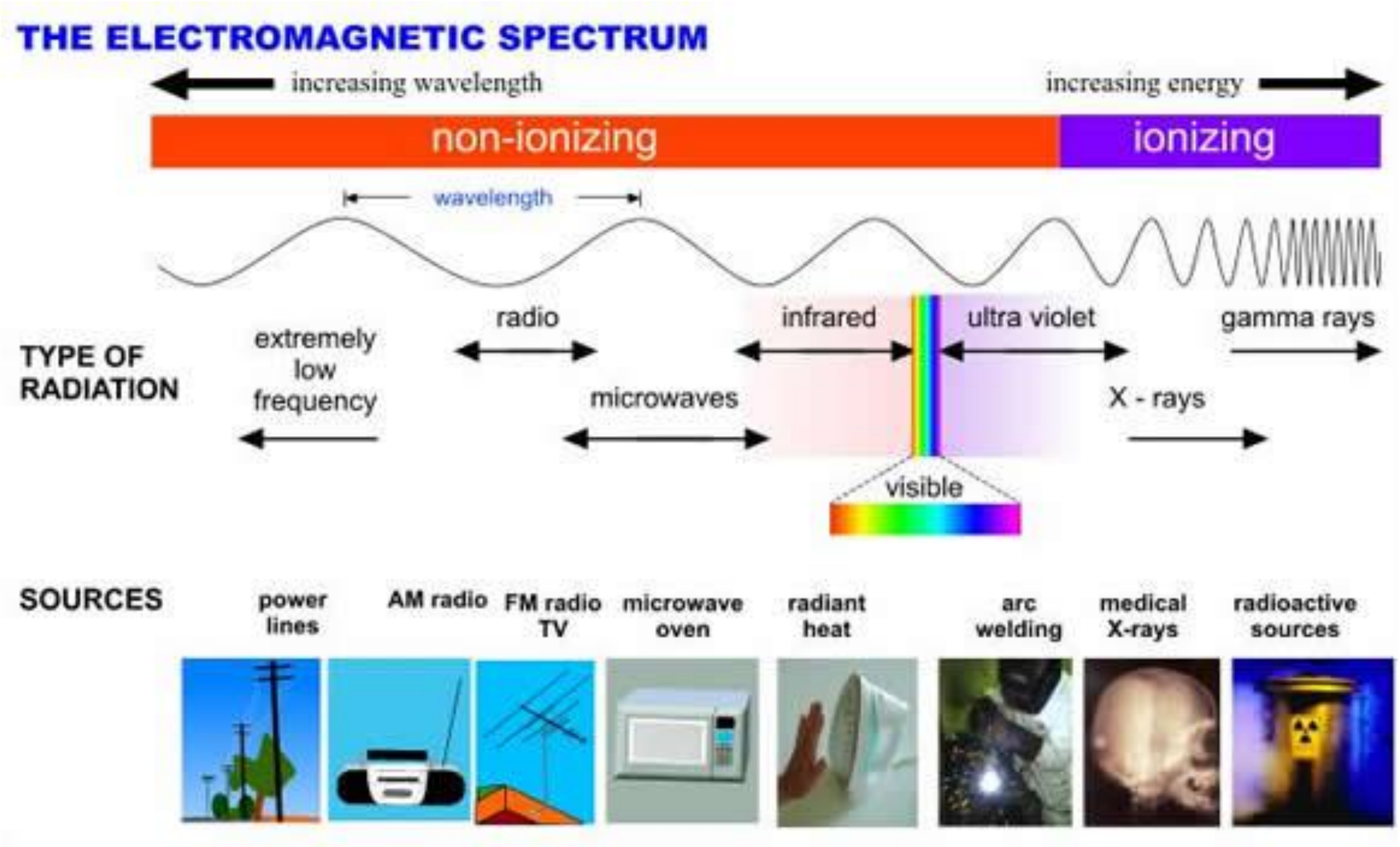
Energy from the sun reaches the earth mainly in the form of visible and UV radiation, whereas the flowing coals of a fireplace transmit heat energy by infrared radiation.

Fun fact: Practically all the fuels that modern society uses – gas, oil and coal – are stored forms of energy received from the sun as electromagnetic radiation millions of years ago. Only energy from nuclear reactors does not originate from the sun.

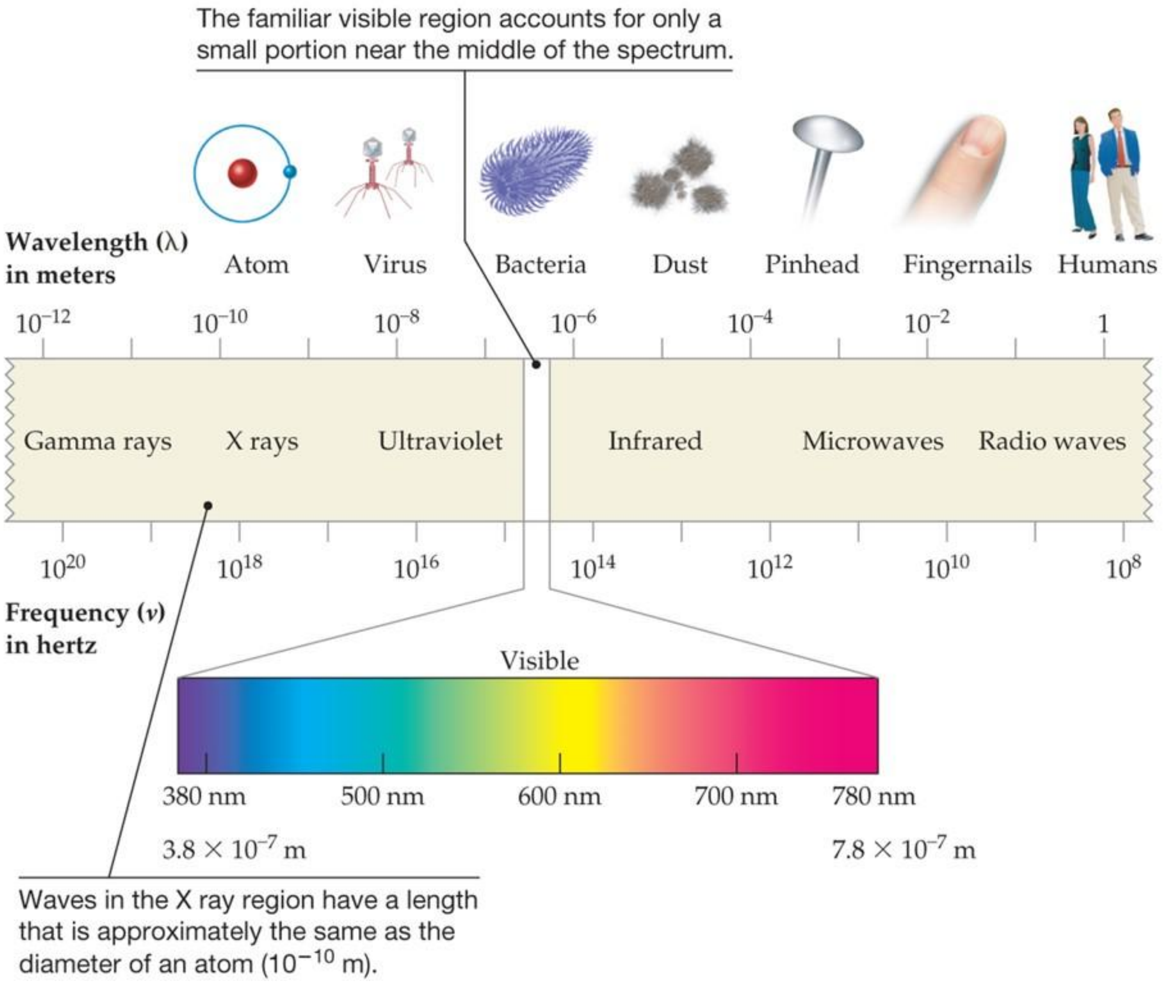
Britannica: Electromagnetic radiation | Spectrum, Examples, & Types | Britannica

Radiation provides an important means of energy transfer.

Classification of Electromagnetic Radiation



Wave Properties of Radiant Energy and the Electromagnetic Spectrum – Frequency Is Inversely Proportional to Wavelength



$\upsilon \uparrow \lambda \downarrow$

Wave Properties of Radiant Energy and the Electromagnetic Spectrum

Wavelength	$\times$	Frequency	$=$	Speed
λ	$\times$	ν	$=$	c
m		$\dfrac{1}{\text{s}}$		$\dfrac{\text{m}}{\text{s}}$

c is defined to be the rate of travel of all electromagnetic energy in a vacuum and is a constant value—**speed of light**.

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

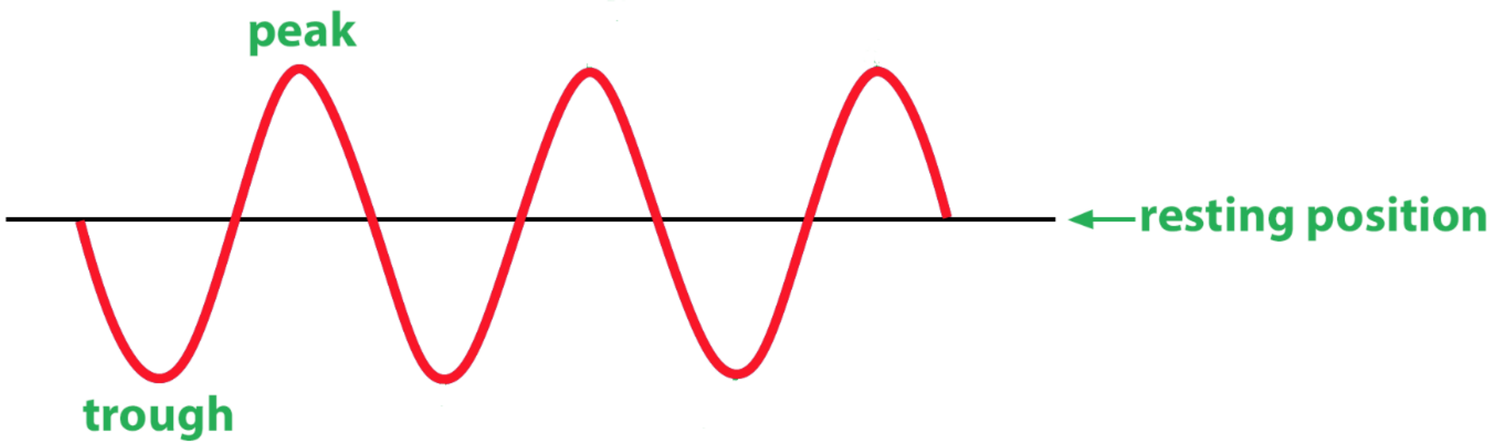
End of the 19th Century

- It was thought that all major problems in physics had been solved.
- That matter and energy were distinct
  - Matter was thought to consist of particles that had a measurable mass and easily specified position.
  - Energy in the form of light (electromagnetic radiation) was described as a wave that had no mass and its position could not be precisely defined.
  - There was no overlap in characteristics!

Is any of this true today?

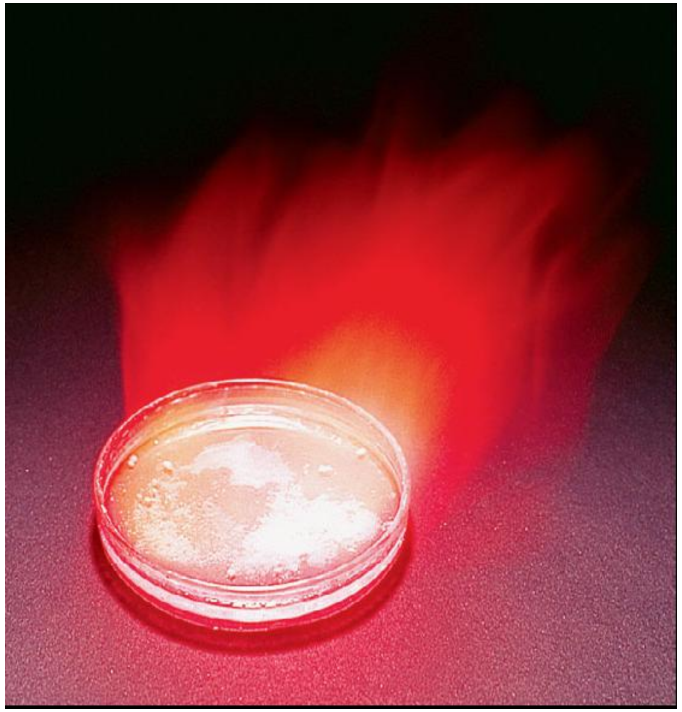
Exercise 1

Identify the following terms on the transverse wave shown below: amplitude and wavelength.



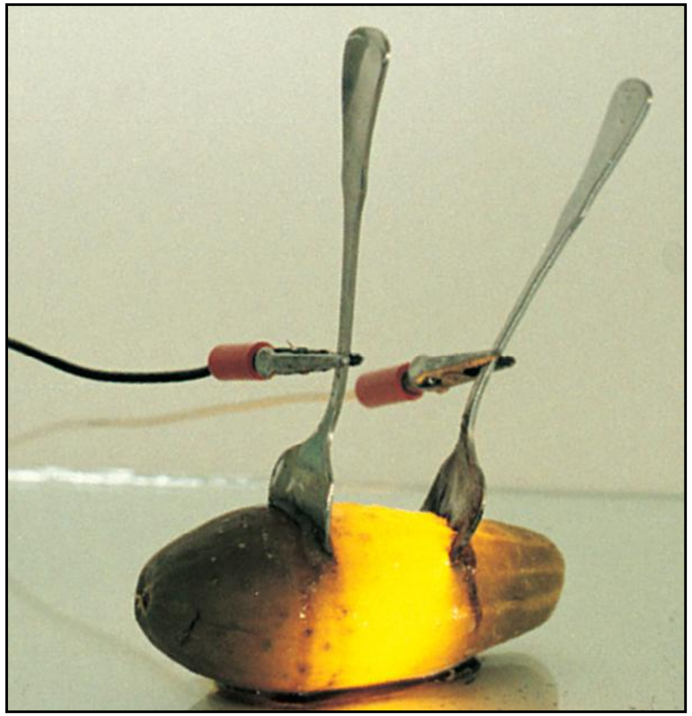
Exercise 2

The brilliant red colours seen in fireworks are due to the emission of light with wavelengths around 650 nm when strontium salts, such as $Sr(NO_3)_2$ and $SrCO_3$, are heated. Calculate the frequency of red light of wavelength 6.50×10^2 nm.



Exercise 3

When an alternating current of 110 volts is applied to a pickle, a current is conducted due to the high concentration of NaCl present, resulting in a glowing light, an emission at 589 nm. Calculate the frequency of light at this wavelength.



Exercise 4

Streetlamps filled with mercury gas emit a blue light. Sodium lamps emit yellow light.

a. Light from sodium has a wavelength of ~ 589 nm. If a mercury streetlamp has a frequency of 6.88×10^{14} s^{-1} (or Hz), what is its wavelength in nanometers?
b. Does blue light correspond to a longer or shorter wavelength than yellow?