B.Sc. V Semester

Physical Chemistry

Electromagnetic Radiations

Electromagnetic Radiation: Electromagnetic radiation can be defined as a form of energy that is produced by the movement of electrically charged particles travelling through a matter or vacuum or by oscillating magnetic and electric disturbance. The magnetic and the electric fields come at 90° to each other, and the combined waves move perpendicular to both electric and magnetic oscillating fields occurring the disturbance.

Properties of Electromagnetic Radiation

When electromagnetic radiation occurs, the electron radiations are released as photons. These are bundles of light energy or quantized harmonic waves which travel at the speed of light. Then based on the wavelength of the electromagnetic spectrum, the energy is grouped into different categories. These magnetic and electric waves travel perpendicular to each other and have some characteristics like wavelength, amplitude, and frequency. Some basic properties of Electromagnetic Radiation are given in the points mentioned below.

- They can travel through empty space. Waves other than electromagnetic waves have to travel through some substance. For example, sound waves will need either a solid, liquid or gas to pass through.
- The speed of light which is 2.99792458×10^8 m/s is always constant.
- Wavelength is commonly characterized by the symbol 'λ'. It is the measure between the distance of either troughs or crests.

Waves and their Characteristics

Electromagnetic radiation occurs when an atomic particle, like an electron, is accelerated by an electric field, causing it to accelerate. Electromagnetic waves and their characteristics is explained briefly in the points mentioned below.

Wavelength

Wavelength (λ) is the distance between successive crests of a wave, especially points in an electromagnetic wave or sound wave. It can be simply defined as the distance of one full cycle of the oscillation. If 'λ' is the wavelength, 'c' is the speed of light and '*v*' is frequency. Then we can derive the relation given below.

$$c = \lambda v$$

The shorter the wavelength, greater the frequency and greater the frequency, the higher the energy.

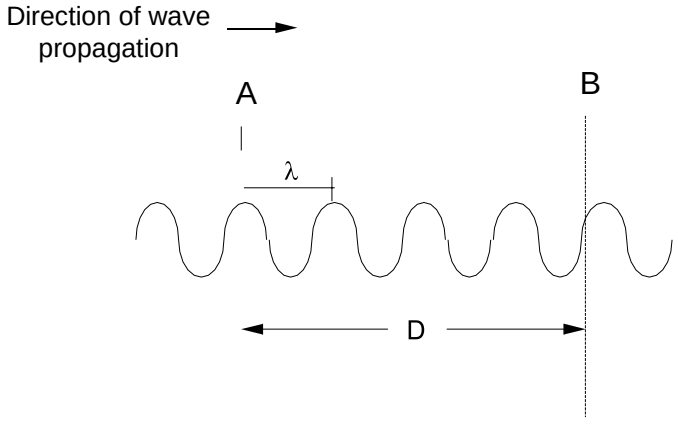
Frequency

The number of cycles per second is defined as Frequency. It is defined as Hertz (Hz) or sec^{-1}. If 'E' is the energy, 'h' is Planck's constant which is equal to 6.62607×10^{-34} and '*v*' is the frequency we can derive the relation given below.

$$E = hv$$

Thus, we can see that frequency is directly proportional to energy.

Relationship of Wavelength and Frequency of Electromagnetic Waves



Speed of light = Wavelength x Frequency

$$\textbf{Wavelength} = \frac{\textbf{Speed of light}}{\textbf{Frequency}}$$

$$\textbf{Frequency} = \frac{\textbf{Speed of light}}{\textbf{Wavelength}}$$

or

$$\mathbf{c = \lambda f}$$

Amplitude

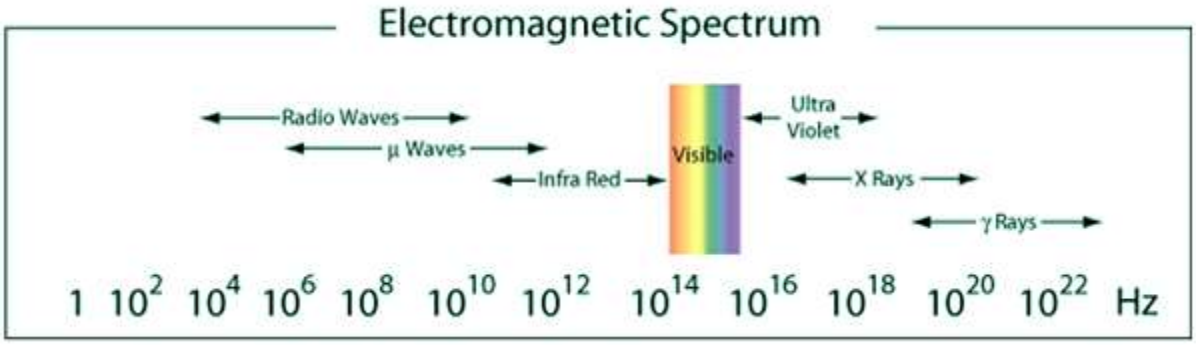
It is the distance from the middle of the wave to the maximum vertical displacement of the wave. Larger the amplitude, higher the energy and lower the amplitude, lower the energy. Amplitude tells us about the brightness or intensity of a wave compared to other waves.

Period

Period is commonly characterised by the symbol 'T'. It is the total time which a wave takes to travel 1 wavelength.

Electromagnetic Spectrum

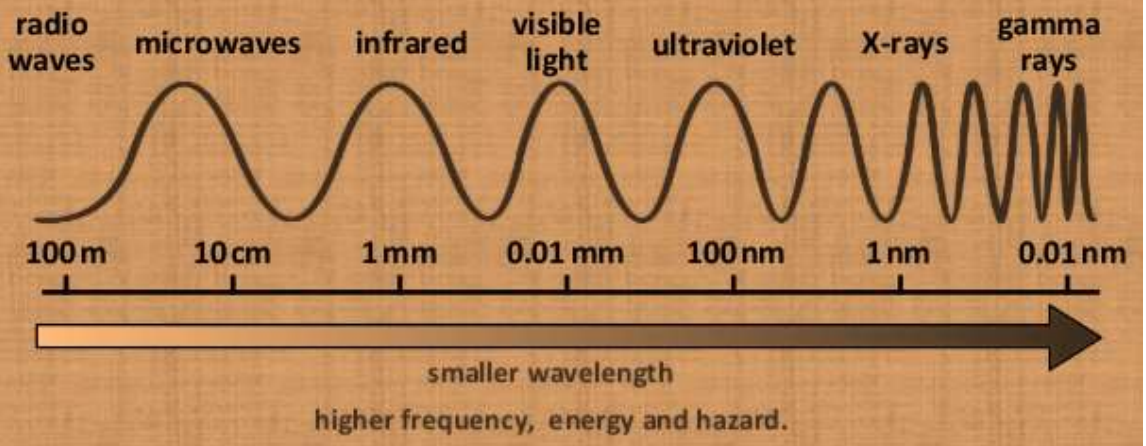
Electromagnetic spectrum is the range of frequencies EM radiations along with their associated wavelengths and photon energies. It consists of Gamma-rays, X-rays, ultraviolet rays, infrared rays, radio waves, microwaves. Electromagnetic radiations have a wide range of frequencies, wavelengths and photon energy levels. These waves travel at the speed of light in vacuum.



Light waves of various frequency in electromagnetic spectrum

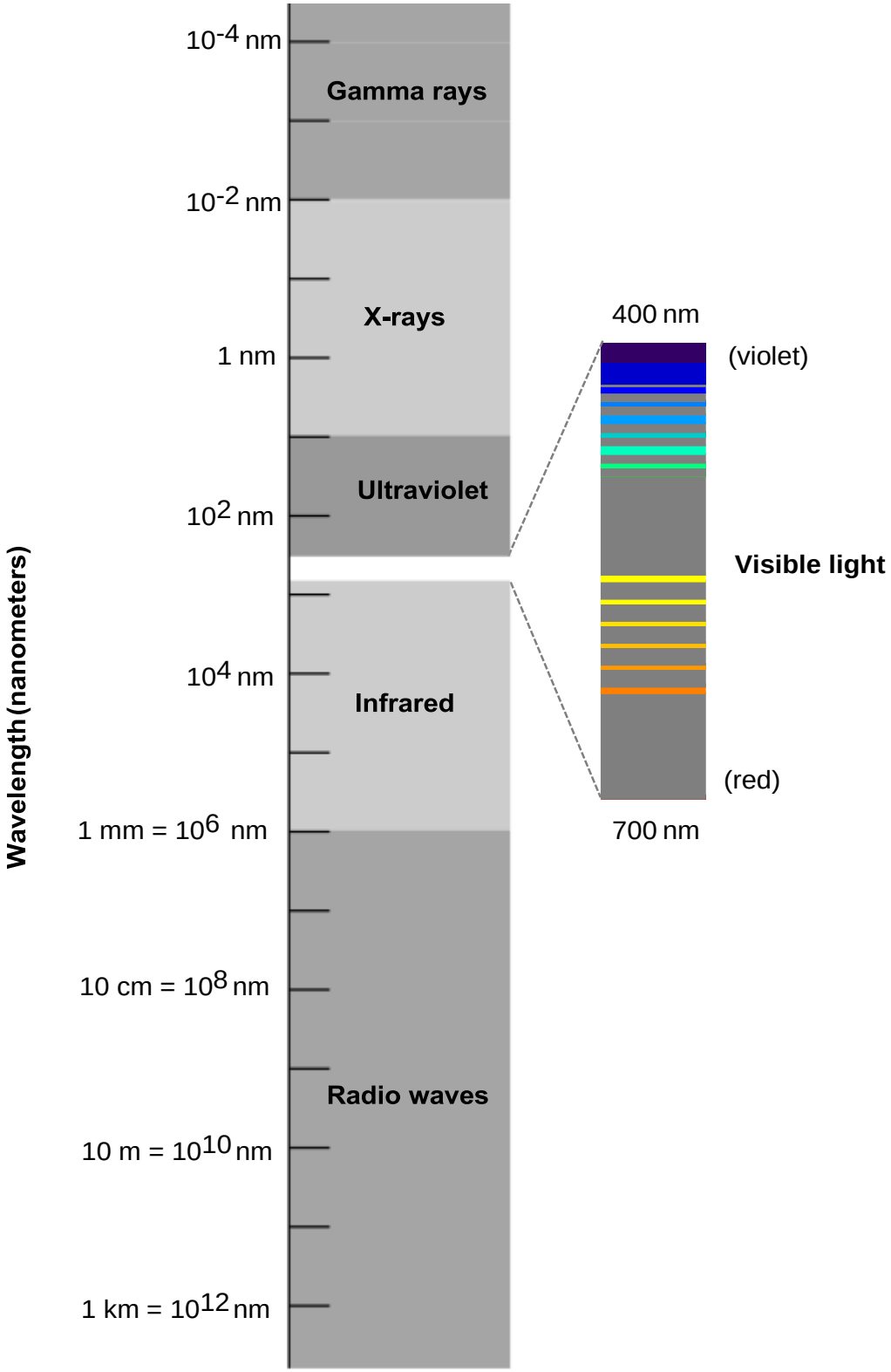
- Electromagnetic Spectrum is the range of all possible frequencies of electromagnetic radiation.
- EMR extends over a wide range of energies or wavelengths or frequencies.

The electromagnetic waves are grouped into types that have similar wavelengths and so have similar properties.

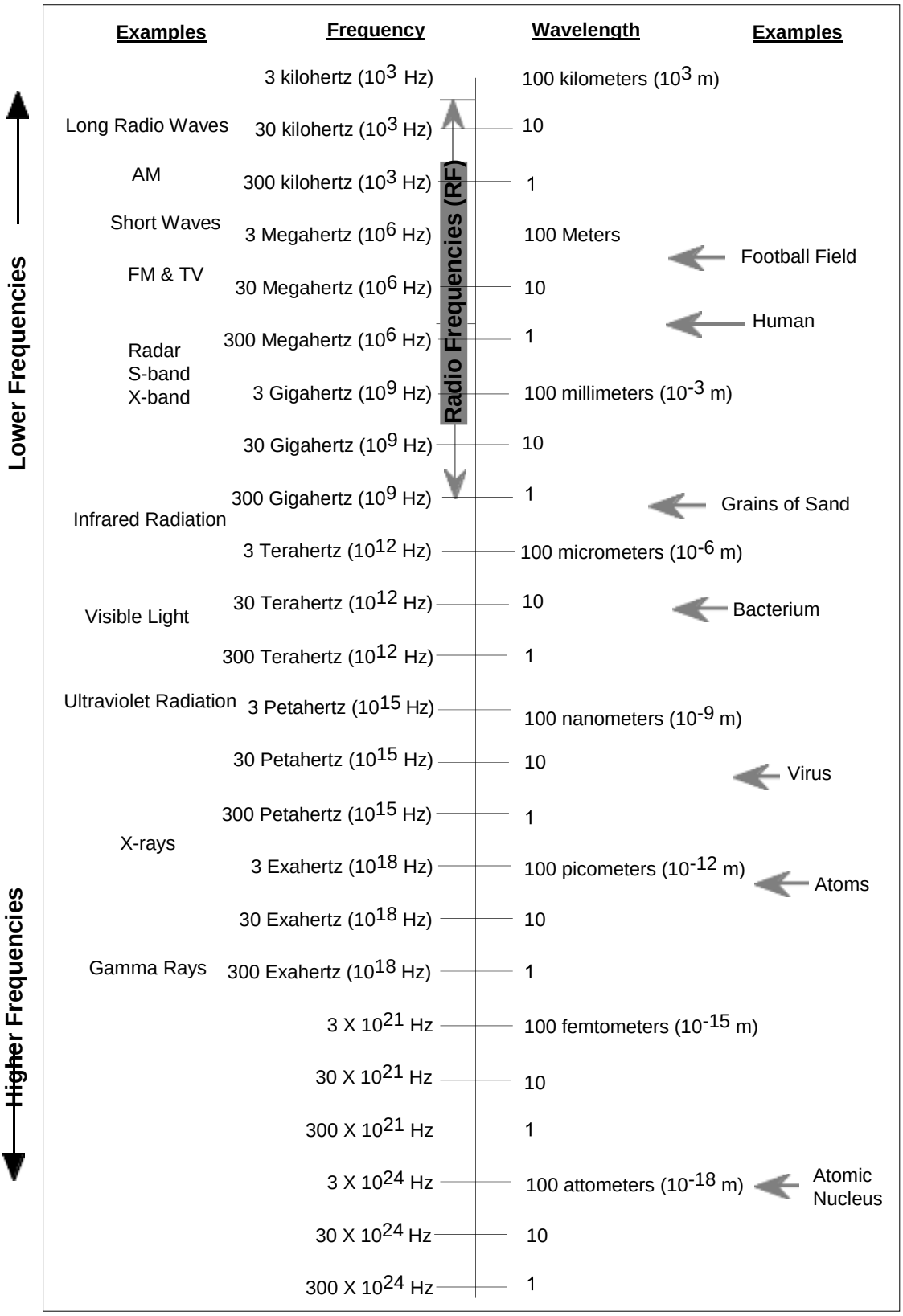


Electromagnetic waves form a **continuous series** in order of changing wavelength, frequency and energy. This series is called the **electromagnetic spectrum**.

Electromagnetic Spectrum:
Visible light only a fraction of the spectrum



The Electromagnetic Spectrum: Wavelength/frequency chart



Electromagnetic radiation with frequencies between about 5 kHz and 300 GHz is referred to as radio frequency (RF) radiation. Radio frequencies are divided into ranges called "bands," such as "S-band," "X-band," etc. Radio telescopes can be tuned to listen for frequencies within certain bands.

Band	Range of Wavelengths (cm)	Frequency (GHz)
L	30 -15	1 – 2
S	15 - 7.5	2 – 4
C	7.5 - 3.75	4 – 8
X	3.75 - 2.4	8 – 12
K	2.4 - 0.75	12 – 40

The GAVRT can observe S-band and X-band frequencies. Much of radio astronomy involves studies of radiation well above these frequencies.