Unit-I

Spectroscopy: Fundamental Concept

Electromagnetic radiations:

Electromagnetic radiation is a simple harmonic wave moving in a straight line unless it is reflected or refracted. It has two components-**magnetic component and electric component** at right angle to each other as shown in figure 1

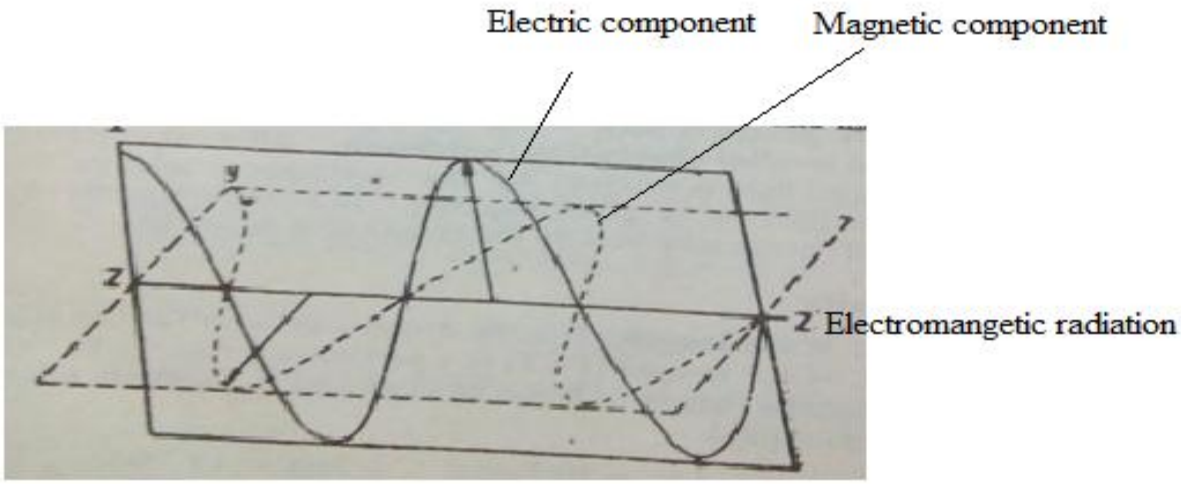

Fig. 1: Components of electromagnetic radiation

On the other hand **electromagnetic spectrum** is a well ordered arrangement of electromagnetic radiations in increasing or decreasing order of wavelength. Characteristic properties associated with electromagnetic radiations or spectrum are: **wavelength, frequency, wave number** and **energy.**

Wavelength: It is defined as the minimum distance between two maxima or minima of either electrical or magnetic component of electromagnetic radiations. It is denoted by λ and it is expressed in different units such as meters, cm or Å.

Frequency: It is the number of waves passing through a point in unit time. Frequency is denoted by υ, whose unit is Hz or s^{-1}.

Wave number: It is the reciprocal of wavelength, which is denoted by $\bar{\upsilon}$. It is expressed in cm^{-1} and energy in joules

Energy: The energy of a wave is associated with the frequency of radiations as

$$E = h\,\upsilon$$

Where *h* is the plank's constant and υ is the frequency of light

The visible spectrum represents only a small part of electromagnetic radiations. When we arrange parts of electromagnetic radiations in order of their increasing wavelength then the portion above the visible region is called infrared while that below it is the uv region. Cosmic rays carry high energy while radiowaves are least energetic. Microwaves have higher wavelength and are used in telephone transmission.

In an electromagnetic spectrum, we may note that:

(i) **Visible and uv** radiations which covers the wavelength range from 200 – 800mμ. The absorption of radiation in this region causes the excitation of π electrons in molecules (unsaturated molecules, aldehydes, ketones etc.)

(ii) The **infrared** radiation which covers the wavelength from 0.8 – 2.5μ constitute near infrared region and that from 15 to 25μ is called far infrared region. The most useful region for infrared spectroscopy is 2.5 - 15μ. This radiations are of higher wavelength and hence less energetic. When such radiations falls on an organic molecule cause molecular vibrations. The changes in the vibrational levels are accompanied by the changes in rotational levels. Thus, certain bands appear which characteristically absorb for the stretching vibrations and are very useful for structural elucidation. The absorption at higher wavelength in the infrared region is most characteristic of a compound and also help in distinguishing one compound form the other.

(iii) **NMR spectroscopy** provides a complete insight into the environment and the arrangement of atoms within a molecule. For this technique, radiation of longest wavelength range i.e. Radiofrequency waves are generally useful. It involves the interaction between an oscillating magnetic field of electromagnetic radiations and the magnetic energy of the hydrogen nucleus or some other type of nuclei when these are place in an external static magnetic field.

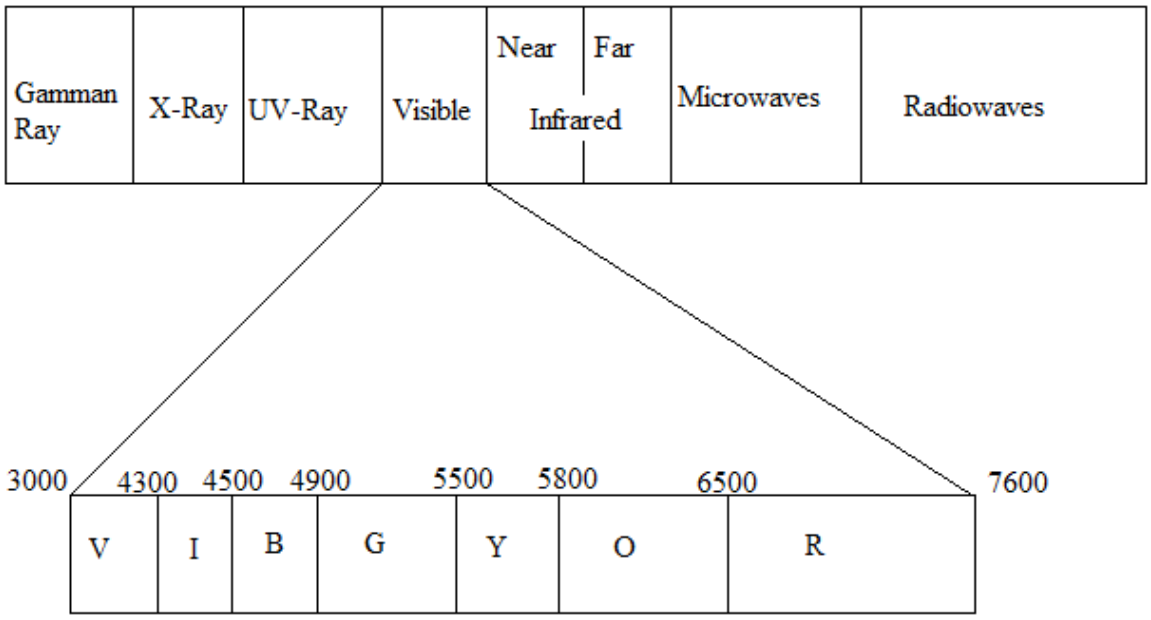

Fig.2: Electromagnetic Spectrum

Absorption and Emission Spectrum

If electromagnetic radiations of certain wavelength range are passed through the substance under analysis for a particular time, then the radiation of certain wavelength are absorbed by the substance. Due to the absorption of wavelength by the substance dark pattern of lines are appear which is called absorption spectrum. After absorption, the transmitted light is analysed by the sepectrometer called emission spectrum which is relative to the incident light of a given frequency.

Conceptual Questions

1. What do you mean by electromagnetic radiations and electromagnetic spectrum? How do the wavelength and energy of different types electromagnetic radiations vary?
2. Arrange different electromagnetic spectrum in order of their wavelength:
   UV visible-ray, Gamma ray, Infrared ray, Radiofrequency ray
3. What are the important characteristics of electromagnetic radiations?
4. What is Absorption and emission spectra of electromagnetic radiations?
5. What are the ranges of frequencies for uv-visible and NMR spectroscopy?
6. The wavelength associated with uv-region is 285 nm. Determine the energy associated with it in term of kcal mol^{-1}
7. What types of energy change takes place when (i) uv-visible,(ii) infrared light is passing through molecules

References:

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2. Spectroscopy (Atomic and Molecular), 3rd Edn, G. Chatwal, S. Anand, Himalaya Pub. House, Bombay.
3. Engineering Chemistry (Edited Book), 2nd Edn, Wiley India, New Delhi.

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