THE ELECTROMAGNETIC SPECTRUM

Name	Frequency Range (Hz)	Wavelength Range	Production	Detection	Main Properties and uses
Radiowaves	10^4 to 10^8	> 0.1 m	Rapid acceleration and decelerations of electrons in aerials/ antenna.	Receiver's aerials.	Different specialised uses in radio communication.
Microwaves	10^8 to 10^{12}	0.1 m to 1mm	Klystron valve or magnetron valve.	Point contact diodes.	(a) Radar communication. (b) Analysis of fine details of molecular and atomic structure.
Infrared waves	3×10^{11} to 4×10^{14}	1mm to 700nm	Vibration of atoms and molecules.	Thermopiles Bolometer, Infra-red and photographic film.	(a) Useful for molecular structure. (b) Useful for haze photography.
Visible rays	4×10^{14}	700 nm to 400 nm	Electrons in atoms emit light when they move from one energy level to a lower energy level.	Human eye, Photocells and Photographic film.	Our eyes are sensitive to this range of wavelengths.
Ultraviolet rays	to 7×10^{14} 10^{14} to 10^{16}	400 nm to 1 nm	Inner shell electrons in atoms moving from one energy level to a lower level.	Photocells and Photographic film.	(a) Absorbed by glass (b) Can cause the tanning of the human skin. (c) Ionize atoms in atmosphere, resulting in the ionosphere.
X-rays	10^{16} to 10^{19}	1 nm to 10^{-3} nm	X-ray tubes or inner shell electrons.	Photographic film, Geiger tubes and Ionization chamber.	(a) Penetrate matter (e.g., radiography) (b) Ionize gases (c) Cause fluorescence (d) Cause photoelectric emission from metals.
Gamma rays	10^{18} to 10^{22}	< 10^{-3} nm	Radioactive decay of the nucleus.	Photographic film, Geiger tubes and Ionization chamber.	Similar to X-rays.

Illustration 4

Obtain the photon energy in units of eV for different parts of the Em spectrum. In what way are the different scales of photon energies that you obtain related to the sources of electromagnetic radiation?

Soln.: The photon of given energy are released during transition between energy levels in the atom and the emitted photon energy is equal to difference of energies of energy levels, among which the transition has taken place.

For $\lambda = 1$ m

$$E = h\upsilon = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{1}\text{ J}$$

$$E = \frac{19.89\times10^{-26}}{1.6\times10^{-19}}\text{ eV} = 12.425\times10^{-7}\text{ eV}$$

So, for emission of radio waves the energy difference between energy levels should be 12.425×10^{-7} eV.

Similarly, photon energy for other wavelengths can also be calculated

Type of Radiation	Wavelength of Radiation	Photon Energy
1. Radio waves	1 m	12.425×10^{-7} eV
2. Microwaves	3×10^{-3} m	4.14×10^{-4} eV
3. Infrared waves	3×10^{-5} m	4.14×10^{-2} eV
4. Visible rays	5×10^{-7} m	2.485 eV
5. Ultraviolet rays	3×10^{-7} m	4.14 eV
6. X-rays	10^{-10} m	12.425×10^{3} eV
7. γ-rays	10^{-12} m	12.425×10^{5} eV

So, for emission of γ rays the energy difference among energy levels should be of the order of MeV, where for visible radiation it should be of the order of eV.