



Question 8.13:

Use the formula $\lambda_m T = 0.29 \text{ cm K}$ to obtain the characteristic temperature ranges for different parts of the electromagnetic spectrum. What do the numbers that you obtain tell you?

Answer

A body at a particular temperature produces a continuous spectrum of wavelengths. In case of a black body, the wavelength corresponding to maximum intensity of radiation is given according to Planck's law. It can be given by the relation,

$$\lambda_m = \frac{0.29}{T} \text{ cm K}$$

Where,

λ_m = maximum wavelength

T = temperature

Thus, the temperature for different wavelengths can be obtained as:

$$\text{For } \lambda_m = 10^{-4} \text{ cm; } T = \frac{0.29}{10^{-4}} = 2900 \text{ } ^\circ\text{K}$$

$$\text{For } \lambda_m = 5 \times 10^{-5} \text{ cm; } T = \frac{0.29}{5 \times 10^{-5}} = 5800 \text{ } ^\circ\text{K}$$

$$\text{For } \lambda_m = 10^{-6} \text{ cm; } T = \frac{0.29}{10^{-6}} = 290000 \text{ } ^\circ\text{K} \text{ and so on.}$$

The numbers obtained tell us that temperature ranges are required for obtaining radiations in different parts of an electromagnetic spectrum. As the wavelength decreases, the corresponding temperature increases.

Question 8.14:

Given below are some famous numbers associated with electromagnetic radiations in different contexts in physics. State the part of the electromagnetic spectrum to which each belongs.

(a) 21 cm (wavelength emitted by atomic hydrogen in interstellar space).

(b) 1057 MHz (frequency of radiation arising from two close energy levels in hydrogen; known as Lamb shift).

(c) 2.7 K [temperature associated with the isotropic radiation filling all space-thought to be a relic of the 'big-bang' origin of the universe].

(d) 5890 Å - 5896 Å [double lines of sodium]

(e) 14.4 keV [energy of a particular transition in ^{57}Fe nucleus associated with a famous high resolution spectroscopic method (Mössbauer spectroscopy)].

Answer

(a) Radio waves; it belongs to the long wavelength end of the electromagnetic spectrum.

(b) Radio waves; it belongs to the long wavelength end.

(c) Temperature, $T = 2.7 \text{ } ^\circ\text{K}$

λ_m is given by Planck's law as:

$$\lambda_m = \frac{0.29}{2.7} = 0.11 \text{ cm}$$

This wavelength corresponds to microwaves.

(d) This is the yellow light of the visible spectrum.

(e) Transition energy is given by the relation,

$$E = h\nu$$

Where,

h = Planck's constant = $6.6 \times 10^{-34} \text{ Js}$

ν = Frequency of radiation

Energy, $E = 14.4 \text{ KeV}$

$$\begin{aligned} \therefore \nu &= \frac{E}{h} \\ &= \frac{14.4 \times 10^3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} \\ &= 3.4 \times 10^{18} \text{ Hz} \end{aligned}$$

This corresponds to X-rays.

Question 8.15:

Answer the following questions:

- (a)** Long distance radio broadcasts use short-wave bands. Why?
- (b)** It is necessary to use satellites for long distance TV transmission. Why?
- (c)** Optical and radio telescopes are built on the ground but X-ray astronomy is possible only from satellites orbiting the earth. Why?
- (d)** The small ozone layer on top of the stratosphere is crucial for human survival. Why?
- (e)** If the earth did not have an atmosphere, would its average surface temperature be higher or lower than what it is now?
- (f)** Some scientists have predicted that a global nuclear war on the earth would be followed by a severe 'nuclear winter' with a devastating effect on life on earth. What might be the basis of this prediction?

Answer

- (a)** Long distance radio broadcasts use shortwave bands because only these bands can be refracted by the ionosphere.
- (b)** It is necessary to use satellites for long distance TV transmissions because television signals are of high frequencies and high energies. Thus, these signals are not reflected by the ionosphere. Hence, satellites are helpful in reflecting TV signals. Also, they help in long distance TV transmissions.
- (c)** With reference to X-ray astronomy, X-rays are absorbed by the atmosphere. However, visible and radio waves can penetrate it. Hence, optical and radio telescopes are built on the ground, while X-ray astronomy is possible only with the help of satellites orbiting the Earth.
- (d)** The small ozone layer on the top of the atmosphere is crucial for human survival because it absorbs harmful ultraviolet radiations present in sunlight and prevents it from reaching the Earth's surface.
- (e)** In the absence of an atmosphere, there would be no greenhouse effect on the surface of the Earth. As a result, the temperature of the Earth would decrease rapidly, making it chilly and difficult for human survival.
- (f)** A global nuclear war on the surface of the Earth would have disastrous consequences. Post-nuclear war, the Earth will experience severe winter as the war will produce clouds of smoke that would cover maximum parts of the sky, thereby preventing solar light from reaching the atmosphere. Also, it will lead to the depletion of the ozone layer.

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