Short Answer Questions – II (PYQ)

Q. 1. How are electromagnetic waves produced? What is the source of energy of these waves? Write mathematical expressions for electric and magnetic fields of an electromagnetic wave propagating along the z-axis. Write any two important properties of electromagnetic waves. [CBSE North 2016]

Ans. EM waves are produced by oscillating charged particle.

Mathematical expression for electromagnetic waves travelling along z-axis:

$E_x = E_0 \sin (kz - \omega t)$ and [For electric field]

$B_y = B_0 \sin (kz - \omega t)$ [For magnetic field]

Properties

(i) Electromagnetic waves have oscillating electric and magnetic fields along mutually perpendicular directions.

(ii) They have transverse nature.

Q. 2. Arrange the following electromagnetic waves in the order of their increasing wavelength:

(a) γ-rays **(b) Microwaves**

(c) X-rays **(d) Radio waves**

How are infra-red waves produced? What role does infra-red radiation play in (i) maintaining the Earth's warmth and (ii) physical therapy? [CBSE Panchkula 2015]

Ans. γ rays < X rays < Microwaves < Radio waves

Infra-red rays are produced by the vibration of atoms and molecules.

(i) Maintaining Earth's Warmth: Infrared rays are absorbed by the earth's surface and reradiated as longer wave length infrared rays. These radiations are trapped by greenhouse gases such as CO_2 and maintain earth's warmth.

(ii) Physical Therapy: Infrared rays are easily absorbed by water molecules present in body. After absorption, their thermal motion increases causing heating which is used as physical therapy.

Q. 3. Answer the following questions:

Which one of the following electromagnetic radiations has least frequency:

(i) UV radiations, X-rays, Microwaves?

(ii) How do you show that electromagnetic waves carry energy and momentum?

(iii) Write the expression for the energy density of an electromagnetic wave propagating in free space. [CBSE Bhubaneswar 2015]

Ans. (i) Microwave

(ii) When a charge oscillates with some frequency. It produces an oscillating electric field and magnetic field in space. So, an electromagnetic wave is produced.

The frequency of the em wave is equal to the frequency of oscillation of the charge.

Hence energy associated with the em wave comes at the expense of the energy of the source.

If the em wave of energy U strikes on a surface and gets completely absorbed, total momentum delivery to the surface is p = $\frac{U}{E}$.

(iii) The em wave consists of oscillating electric and magnetic fields, so net energy density of em wave is

$$U = U_E + U_B$$

$$U = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$$

Q. 4. Answer the following questions:

(i) How are electromagnetic waves produced by oscillating charges?

(ii) State clearly how a microwave oven works to heat up a food item containing water molecules.

(iii) Why are microwaves found useful for the radar systems in aircraft navigation?
[CBSE (F) 2013]

Ans. (i) If a charge particle oscillates with some frequency, produces an oscillating electric field in space, which produces an oscillating magnetic field, which inturn, is a source of electric field, and so on. Thus oscillating electric fields and magnetic fields regenerate each other, and an electromagnetic wave propagates in the space.

(ii) In microwave oven, the frequency of the microwaves is selected to match the resonant frequency of water molecules so that energy from the waves get transferred efficiently to the kinetic energy of the molecules. This kinetic energy raises the temperature of any food containing water.

(iii) Microwaves are short wavelength radio waves, with frequency of order of few GHz. Due to short wavelength, they have high penetrating power with respect to atmosphere

and less diffraction in the atmospheric layers. So these waves are suitable for the radar systems used in aircraft navigation.

Q. 5. Name the parts of the electromagnetic spectrum which is

(i) Suitable for radar systems used in aircraft navigation.

(ii) Used to treat muscular strain.

(iii) Used as a diagnostic tool in medicine.

Write in brief, how these waves can be produced. [CBSE Delhi 2015]

Ans. (i) Microwave, (ii) Infrared, (iii) X-rays

Microwave are produced by special vacuum tubes, like klystrons, magnetrons and gunn diodes.

Infrared are produced by the vibrating molecules and atoms in hot bodies.

X-rays are produced by the bombardment of high energy electrons on a metal target of high atomic weight (like tungsten).

Q. 6. Answer the following questions:

Identify the part of the electromagnetic spectrum which is :

(a) Suitable for radar system used in aircraft navigation

(b) Produced by bombarding a metal target by high speed electrons.

(ii) Why does a galvanometer show a momentary deflection at the time of charging or discharging a capacitor? Write the necessary expression to explain this observation.
[CBSE Central 2016]

Ans. (i) Microwaves

X-rays

(ii) Due to conduction current in the connecting wires and the production of displacement current between the plates of capacitor on account of changing electric field.

Current inside the capacitor is given by

$$I_d = \varepsilon_0 \frac{d\varphi_E}{}$$

Q. 7. Answer the following questions:

(i) Name the em-waves which are produced during radioactive decay of a nucleus. Write their frequency range.

(ii) Welders wear special glass goggles while working. Why? Explain.

(iii) Why are infrared waves often called as heat waves? Give their one application.
[CBSE Delhi 2014]

Ans. (i) em waves : γ-rays

Range : 10^{19} Hz to 10^{23} Hz

(ii) This is because the special glass goggles protect the eyes from large amount of UV radiations produced by welding arcs.

(iii) Infrared waves are called heat waves because water molecules present in the materials readily absorb the infrared rays and get heated up.

Application: They are used in green houses to warm the plants.

Q. 8. Answer the following:

(i) Name the em waves which are used for the treatment of certain forms of cancer. Write their frequency range.

(ii) Thin ozone layer on top of stratosphere is crucial for human survival. Why?

(iii) Why is the amount of the momentum transferred by the em waves incident on the surface so small? [CBSE Delhi 2014]

Ans. (i) X rays or γ rays

Range: 10^{18} Hz to 10^{22} Hz.

(ii) Ozone layer absorbs the ultraviolet radiations from the sun and prevents it from reaching the earth's surface.

(iii) Momentum transferred, p = $\frac{u}{c}$

Where u = energy transferred, and c = speed of light

Due to the large value of speed of light (c), the amount of momentum transferred by the em waves incident on the surface is small.

Short Answer Questions – II (OIQ)

Q. 1. Answer the following:

(i) Name the em waves which are suitable for radar systems used in aircraft navigation. Write the range of frequency of these waves.

(ii) If the earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now? Explain.

(iii) An em wave exerts pressure on the surface on which it is incident. Justify.

Ans. (i) Frequency range : 10^{10} Hz to 10^{12} Hz

(ii) Average surface temperature will be lower. This is because there will be no greenhouse effect in absence of atmosphere.

(iii) An electromagnetic wave exerts pressure on the surface on which it is incident because these waves carry both energy and momentum.

Q. 2. Electromagnetic waves with wavelength

(i) λ_1 is used in satellite communication.
(ii) λ_2 is used to kill germs in water purifier.
(iii) λ_3 is used to detect leakage of oil in underground pipelines.
(iv) λ_4 is used to improve visibility in runways during fog and mist conditions.

(1) Identify and name the part of electromagnetic spectrum to which these radiations belong.

(2) Arrange these wavelengths in ascending order of their magnitude.

(3) Write one more application of each. [NCERT Exemplar]

Ans. (1) $\lambda_1 \rightarrow$ Microwave, $\lambda_2 \rightarrow$ UV $\lambda_3 \rightarrow$ X rays, $\lambda_4 \rightarrow$ Infrared

(2) $\lambda_3 < \lambda_2 < \lambda_4 < \lambda_1$

(3) Microwave – RADAR

UV – LASIK eye surgery

X-ray – Bone fracture identification (bone scanning)

Infrared – Optical communication

Q. 3. Identify the following electromagnetic radiations as per the wavelengths given below.

(a) 10^{-3} nm

(b) 10^{-3} m

(c) 1 nm

Write one application of each.

Ans. (a) 10^{-3} nm $\rightarrow$ gamma radiation.

Application: Radio therapy or to initiate nuclear reactions.

(b) 10^{-3} m → microwaves

Application: In RADAR for aircraft navigation.

(c) 1 nm → X-ray.

Application: In medical science for detection of fractures, stones in kidney, gallbladder etc.

Q. 4. Identify the following electromagnetic radiations as per the frequencies given below:

(a) 10^{20} Hz

(b) 10^{9} Hz

(c) 10^{11} Hz

Write one application of each.

Ans. (a) 10^{20} Hz → γ-radiation.

Application: For treatment of cancer.

(b) 10^{9} Hz → Radio waves

Application: For broadcasting radio-programmes to long distances.

(c) 10^{11}Hz → Microwaves

Application: For cooking in microwave oven.

Q. 5. Experimental observations have shown that X-rays

(i) Travel in vacuum with a speed of 3×10^{8} ms^{-1}

(ii) Exhibit the phenomenon of diffraction and can be polarised.

What conclusion can be drawn about the nature of X-rays from each of these observations?

Ans. (i) X-rays are electromagnetic waves.

(ii) X-rays are transverse in nature.

Q. 6. Which constituent radiation of the electromagnetic spectrum is used

(i) In RADAR,

(ii) To photograph internal parts of a human body, and

(iii) For taking photographs of the sky during night and foggy conditions?

Give one reason for your answer in each case.

Ans. (i) Microwaves are used in RADAR because they go straight and are not absorbed by the atmosphere.

(ii) X-rays are used to photograph the internal parts of human body because they can penetrate light elements (flesh).

(iii) Infrared radiations are used for taking photographs of sky during light and foggy conditions because they penetrate fog and are not absorbed by the atmosphere.