Very Short Answer Questions

Q. 1. How is the speed of em-waves in vacuum determined by the electric and magnetic fields? [CBSE Delhi 2017]

Ans. Speed of em waves is determined by the ratio of the peak values of electric field vector and magnetic field vector.

$$c = \frac{E_0}{B_0}$$

Q .2. Do electromagnetic waves carry energy and momentum? [CBSE (AI) 2017]

Ans. Yes, EM waves carry energy E and momentum P. As electromagnetic waves contain both electric and magnetic fields, there is a non-zero energy density associated with it.

$$E = \frac{hc}{\lambda}$$

$$\Rightarrow \quad P = \frac{U}{c} = mc$$

Here, c = speed of EM wave in vacuum

λ = wavelength of EM wave

U = total energy transferred to the surface.

Q. 3. In which situation is there a displacement current but no conduction current?
[CBSE South 2016]

Ans. During charging or discharging there is a displacement current but no conduction current between plates of capacitor.

Q. 4. The charging current for a capacitor is 0.25 A. What is the displacement current across its plates? [CBSE (F) 2016]

Ans. The displacement current is equal to the charging current. So, displacement current is also 0.25 A.

Q. 5. What are the directions of electric and magnetic field vectors relative to each other and relative to the direction of propagation of electromagnetic waves? [CBSE (AI) 2012]

Ans. Both electric field and magnetic fields are electromagnetic waves. These waves are perpendicular to each other and perpendicular to the direction of propagation.

Q. 6. Name the physical quantity which remains same for microwaves of wavelength 1 mm and UV radiations of 1600 Å in vacuum. [CBSE Delhi 2012]

Ans. Velocity (c = 3×108 m/s)

This is because both are electromagnetic waves.

Q. 7. Write the expression for speed of electromagnetic waves in a medium of electrical permittivity ε and magnetic permeability μ. [CBSE (F) 2017]

Ans. The speed of electromagnetic waves in a material medium in given by

$$c = \frac{1}{\sqrt{\mu\varepsilon}}$$

Q. 8. The speed of an electromagnetic wave in a material medium is given by c= $\frac{1}{\sqrt{\mu\,\epsilon}}$ being the permeability of the medium and ε its permittivity. How does its frequency change? [CBSE (AI) 2012]

Ans. The frequency of electromagnetic waves does not change while travelling through a medium.

Q. 9. A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the direction of electric and magnetic field vectors? [CBSE Delhi 2011]

Ans. Electric field vector along X-axis

Magnetic field vector along Y-axis.

Q. 10. Which part of the electromagnetic spectrum has the largest penetrating power?
[CBSE Delhi 2010]

Ans. γ-rays.

Q. 11. To which part of the electromagnetic spectrum does a wave of frequency 5 × 10^{19} Hz belong? [CBSE (AI) 2014]

Ans. X-rays or γ-rays.

Q. 12. To which part of the electromagnetic spectrum does a wave of frequency 3 × 10^{13} Hz belong? [CBSE (AI) 2014]

Ans. Infrared radiation.

Q. 13. Arrange the following electromagnetic waves in order of increasing frequency:

γ-rays, microwaves, infrared rays and ultraviolet rays. [CBSE (F) 2014]

Ans. Microwave < Infrared < Ultraviolet < γ-rays

Q. 14. Arrange the following electromagnetic waves in decreasing order of wavelength:

γ-rays, infrared rays, X-rays and microwaves. [CBSE (F) 2014]

Ans. Microwave > Infrared > X-rays > γ-rays

Q. 15. Which part of the electromagnetic spectrum is used in operating a RADAR? [CBSE Delhi 2010]

Ans. Microwaves are used in operating a RADAR.

Q. 16. Why are microwaves considered suitable for radar systems used in aircraft navigation? [CBSE Delhi 2016]

Ans. Microwaves are considered suitable for radar systems used in aircraft navigation due to their short wavelength or high frequency.

Q. 17. Which part of the electromagnetic spectrum is absorbed from sunlight by ozone layer? [CBSE Delhi 2010]

Ans. Ultraviolet light is absorbed by the ozone layer.

Q. 18. Welders wear special goggles or face masks with glass windows to protect their eyes from electromagnetic radiations. Name the radiations and write the range of their frequency. [CBSE (AI) 2013]

Ans. Ultraviolet radiations.

Frequency range 10^{15} – 10^{17} Hz.

Hint: Frequency of visible light is of the order of 10^{14} Hz.

Q. 19. Name the electromagnetic waves, which (i) maintain the Earth's warmth and (ii) are used in aircraft navigation. [CBSE (F) 2012]

Ans. (i) Infrared rays **(ii)** Microwaves.

Q. 20. Why are infra-red radiations referred to as heat waves? Name the radiations which are next to these radiations in the electromagnetic spectrum having (i) shorter wavelength (ii) longer wavelength. [CBSE (F) 2013]

Ans. Infrared waves are produced by hot bodies and molecules, so are referred to as heat waves.

(i) Em wave having short wavelength than infrared waves are visible, UV, X-rays and γ-rays.

(ii) Em wave having longer wavelength than infrared waves are microwaves, radio waves.

Q. 21. How are X-rays produced? [CBSE (AI) 2011]

Ans. X-rays are produced when high energetic electron beam is made incident on a metallic target of high melting point and high atomic weight.

Q. 22. Write the following radiations in ascending order in respect of their frequencies: X-rays, microwaves, ultraviolet rays and radio waves and gamma rays.
[CBSE Delhi 2010]

Ans. In ascending order of frequencies: radio waves, microwaves, ultraviolet rays, X-rays and gamma rays.

Q. 23. It is necessary to use satellites for long distance T.V. transmission. Why? [CBSE Delhi 2014]

Ans. T.V. signals are not properly reflected by ionosphere. Therefore, signals are made to be reflected to earth by using artificial satellites.

Q. 24. Optical and radio telescopes are built on the ground but X-ray astronomy is possible only from a satellite orbiting the earth, why? [CBSE (AI) 2009]

Ans. The visible radiations and radio waves can penetrate the earth's atmosphere but X-rays are absorbed by the atmosphere.

Very Short Answer Questions (OIQ)

Q. 1. Identify the type of waves which are produced by the following way and write one application for each:

(i) Radioactive decay of the nucleus

(ii) Rapid acceleration and decelerations of electrons in aerials

(iii) Bombarding a metal target by high energy electrons

Ans.

	Type of wave	**Application**
(i)	Gamma rays	Treatment of tumors

(ii)	Radio waves	Radio and television communication systems
(iii)	X-rays	Study of crystals

Q. 2. What is the origin of displacement current?

Ans. Displacement current does not arise due to motion of charge carriers but it arises due to time variation of electric flux.

Q. 3. What is the unit of ratio $\frac{E}{H}$?

Ans. The unit of $\frac{E}{H}$ is volt/ampere or ohm.

Q. 4. Name the characteristics of electromagnetic waves that

(i) increases
(ii) remains constant.

In the electromagnetic spectrum as one moves from radio wave region towards ultraviolet region.

Ans. (i) Frequency increases.

(ii) Speed in vacuum remains constant.

Q. 5. Which of the following can act as a source of electromagnetic waves

(i) A charge moving with a constant velocity
(ii) A charge moving in a circular orbit
(iii) A charge at rest

Give reason.

Ans. Only an accelerated charge can radiate electromagnetic waves. As charge moving in a circular orbit is accelerated, so it can radiate electromagnetic waves.

Q. 6. Which of the following radiations are (i) heat radiation and (ii) used for long distance transmission? Infrared rays, gamma rays, ultraviolet rays, microwaves.

Ans. Infrared rays are heat radiation, Microwaves are used for long distance transmission.

Q. 7. Which part of electromagnetic spectrum does the wavelength 10^{-10} m correspond to?

Ans. X-rays.

Q. 8. Which of the following has the least wavelength? Gamma rays, blue light, infrared radiation and ultraviolet radiation.

Ans. Gamma rays have the least wavelength.

Q. 9. Which of the following has the minimum wavelength and which has the maximum wavelength?

Blue light, infrared rays, gamma rays, green light.

Ans. Out of the given wavelengths gamma rays have the minimum wavelength and infrared rays have the maximum wavelength.

Q. 10. Identify the part of the electromagnetic spectrum to which the following wavelengths belong:

(i) 10^{-1}m
(ii) 10^{-12}m

Ans. (i) 10^{-1}m = 10 cm belongs to short **radio waves.**

(ii) 10^{-12}m = 0.01 Å belongs to **gamma rays.**

Q. 11. Name the part of the electromagnetic spectrum of wavelength 10^{-2} m and mention its one application.

Ans. Microwave.

Application: Used in RADAR system for aircraft navigation.

Q. 12. Identify the part of the electromagnetic spectrum to which the following wavelengths belong:

(i) 1 mm

(ii) 10^{-11} m

Ans. (i) wavelength 1 mm belongs to the microwaves.

(ii) Wave length 10^{-11} m = 0.1 Å belongs to gamma rays.

Q. 13. Name the electromagnetic radiations used for studying the crystal structure of solids.

Ans. X-rays.

Q. 14. Name the electromagnetic radiations used for viewing objects through haze and fog.

Ans. Infrared rays are used for viewing objects through haze and fog.

Q. 15. Name the part of electromagnetic spectrum which is used for taking photographs of earth under foggy conditions from great heights.

Ans. Infrared radiation.

Q. 16. Name the electromagnetic waves that have frequencies greater than those of ultraviolet light but less than those of gamma rays.

Ans. X-ray.

Q. 17. Name the part of electromagnetic spectrum of wavelength 102 m and mention its one application.

Ans. Wavelength 102 m belongs to radio-waves. This is used to broadcast radio programmes to long distances.

Q. 18. The following table gives the wavelength range of some constituents of the electromagnetic spectrum.

S. No.	Wavelength Range
1.	1 mm to 700 nm
2.	400 nm to 1 nm
3.	1 nm to 10^{-3} nm
4.	< 10^{-3} nm

Select the wavelength range and name the electromagnetic waves that are

(i) Widely used in the remote switches of household electronic devices.
(ii) Produced in nuclear reactions.

Ans. (i) Infrared waves (wavelength range 1 mm to 700 nm).

(ii) Gamma rays (wavelength range <10^{-3} nm).

Q. 19. Special devices, like the klystron valve or the magnetron valve, are used for production of electromagnetic waves. Name the waves and also write one of their applications.

Ans. Name: Microwaves.

Use: For cooking in microwaves ovens.

Q. 20. The frequency of oscillation of the electric field vector of a certain electromagnetic wave is 5 × 1014 Hz. What is the frequency of oscillation of the corresponding magnetic field vector and to which part of the electromagnetic spectrum does it belong?

Ans. Frequency of oscillation of magnetic field vector is same as that of electric field vector i.e.,

$$v = 5 \times 10^{14} \text{ Hz}$$

It lies in visible region.

Q. 21. From the following, identify the electromagnetic waves having the (i) Maximum (ii) Minimum frequency.

(a) Radio waves **(b) Gamma-rays**

(c) Visible light **(d) Microwaves**

(e) Ultraviolet rays, and **(f) Infrared rays.**

Ans. (i) The waves of maximum frequency are gamma rays.

(ii) The waves of minimum frequency are radio waves.

Q. 22. Give a reason to show that microwaves are better carriers of signals for long range transmission than radio waves.

Ans. Microwaves are short wavelength waves, so they go straight in a specified direction without any bending.

Q. 23. Which out of the following are electromagnetic waves: X-rays, sound waves and radio waves?

Ans. X-rays and radio waves are electromagnetic waves.

Q. 24. Is the ratio of frequencies of ultraviolet rays and infrared rays in glass more than, less than or equal to 1?

Ans. Ultraviolet rays have more frequency than infrared rays hence ratio is :

$$\frac{\nu_{\text{ultraviolet}}}{\nu_{\text{infrared}}} = 1$$

Q. 25. Why is the orientation of the portable radio with respect to broadcasting station important? [NCERT Exemplar] [HOTS]

Ans. As electromagnetic waves are plane polarised, so the receiving antenna should be parallel to electric/magnetic part of the wave.

Q. 26. A variable frequency ac source is connected to a capacitor. How will the displacement current change with decrease in frequency?
[NCERT Exemplar] [HOTS]

Ans. On decreasing the frequency, reactance XC = $\frac{1}{\omega C}$ will increase which will lead to decrease in conduction current. In this case $I_D = I_C$, hence displacement current will decrease.

Q. 27. Professor C.V. Raman surprised his students by suspending freely a tiny light ball in a transparent vacuum chamber by shining a laser beam on it. Which

property of em waves was he exhibiting? Give one more example of this property. [NCERT Exemplar] [HOTS]

Ans. Electromagnetic waves exert radiation pressure. Tails of comets are due to solar radiation.

Q. 28. What physical quantity is the same for X-rays of wavelength 10^{-10} m, red light of wavelength 6800 Å and radio waves of wavelength 500 m?

Ans. X-rays, red light and radio waves are all electromagnetic waves. The speed of propagation in vacuum is the same for all these waves. This speed is equal to $c = 3 \times 10^8$ m/s.

Q. 29. A charged particle oscillates about its mean (equilibrium) position with a frequency of 10^9 Hz. What is the frequency of the electromagnetic waves produced by the oscillator?

Ans. According to Maxwell's theory, an oscillating charged particle with a frequency v radiates electromagnetic waves of frequency v.

So the frequency of electromagnetic waves produced by the oscillator is $v = 10^9$ Hz

Q. 30. Long distance radio broadcasts use short wave bands, why?

Ans. Radio broadcasts use the reflection of transmitted waves through different ionospheric layers. These layers reflect short wavelength bands.

Q. 31. How are infrared waves produced?

Ans. Infrared waves are produced by hot bodies and molecules.

Short Answer Questions – I (PYQ)

Q. 1. State two properties of electromagnetic waves. How can we show that em waves carry momentum? [CBSE South 2016]

Ans. Properties of electromagnetic waves:

(i) Transverse nature.

(ii) Does not get deflected by electric or magnetic fields.

(iii) Same speed in vacuum for all waves.

(iv) No material medium required for propagation.

(v) They get refracted, diffracted and polarised.

Electric charges present on a plane, kept normal to the direction of propagation of an em wave can be set and sustained in motion by the electric and magnetic field of the electromagnetic wave. The charges thus acquire energy and momentum from the waves.

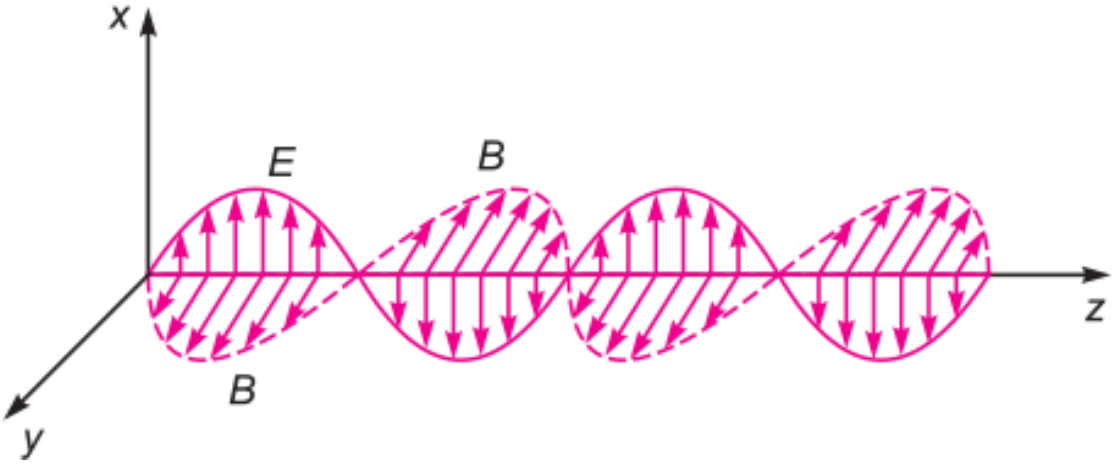
Q. 2. Answer the following questions:

(i) How does oscillating charge produce electromagnetic waves?

(ii) Sketch a schematic diagram depicting oscillating electric and magnetic fields of an em wave propagating along + z-direction. [CBSE (F) 2014, Delhi 2016]

Ans. (i) An oscillating charge produces an oscillating electric field in space, which produces an oscillating magnetic field. The oscillating electric and magnetic fields regenerate each other, and this results in the production of em waves in space.

(ii) Electric field is along x-axis and magnetic field is along y-axis.



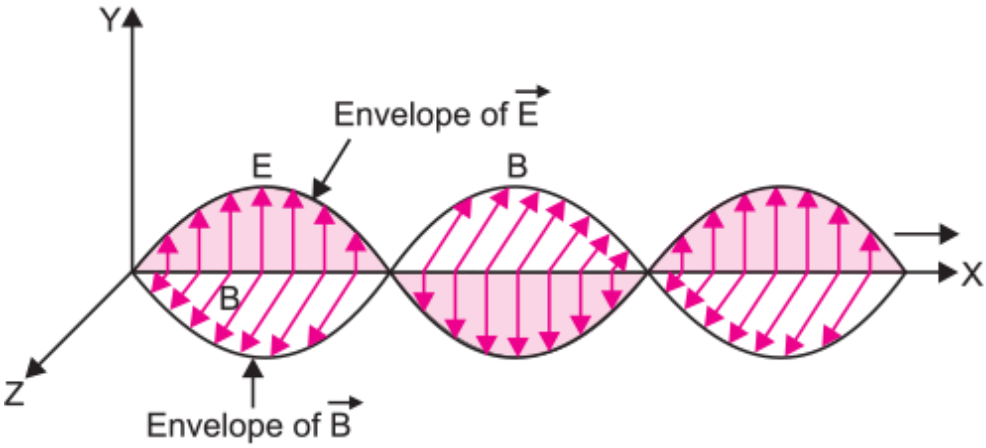
Q. 3. Answer the following questions:

(i) An em wave is travelling in a medium with a velocity $\underset{v}{\rightarrow} = v\,\hat{i}$. Draw a sketch showing the propagation of the em wave, indicating the direction of the oscillating electric and magnetic fields.

(ii) How are the magnitudes of the electric and magnetic fields related to the velocity of the em wave? [CBSE Delhi 2013]

Ans. (i) $\hat{i} = \hat{j} \times \hat{k}.$

The direction of propagation of electromagnetic wave is given by $\underset{E}{\rightarrow} \times \underset{B}{\rightarrow}$



(ii) The speed of electromagnetic wave |c|= $\frac{|E_0|}{|B_0|}$

Q. 4. Name the part of the electromagnetic spectrum whose wavelength lies in the range 10^{-10} m. Give its one use.[CBSE (AI) 2010]

Ans. The electromagnetic waves having wavelength 10^{-10} m are X-rays.

X-rays are used to study crystal structure.

Q. 5. Answer the following questions:

(i) How are infrared waves produced? Write their one important use.

(ii) The thin Ozone layer on top of the stratosphere is crucial for human survival. Why?
[CBSE East 2016]

Ans. (i) Infrared waves are produced by hot bodies and molecules.

Important use:

(a) To treat muscular strains. (b) To reveal the secret writings on the ancient walls. (c) For producing dehydrated fruits (d) Solar heater (e) Solar cooker. (Any one)

(ii) Ozone layer protects us from harmful U–V rays.

Q. 6. Answer the following questions:

(i) Which segment of electromagnetic waves has highest frequency? How are these waves produced? Give one use of these waves.

(ii) Which EM waves lie near the high frequency end of visible part of EM spectrum? Give its one use. In what way this component of light has harmful effects on humans?
[CBSE (F) 2016]

Ans. (i) Gamma rays have the highest frequency. These are produced during nuclear reactions and also emitted by radioactive nuclei. They are used in medicine to destroy cancer cells.

(ii) Ultraviolet rays lie near the high frequency end of visible part of EM spectrum. They are used to sterlise drinking water and surgical instruments. Exposure to UV radiation induces the production of more melanin, causing tanning of the skin.

Q. 7. Explain briefly how electromagnetic waves are produced by an oscillating charge. How is the frequency of em waves produced related to that of the oscillating charge?
[CBSE (F) 2012]

Ans. An oscillating or accelerated charge is supposed to be source of an electromagnetic wave. An oscillating charge produces an oscillating electric field in space which further produces an oscillating magnetic field which in turn is a source of electric field. These oscillating electric and magnetic field, hence, keep on regenerating each other and an electromagnetic wave is produced The frequency of em wave = Frequency of oscillating charge.

Q. 8. Identify the electromagnetic waves whose wavelengths vary as

(a) 10^{-12}m < λ < 10^{-8} m
(b) 10^{-3} m < λ < 10^{-1} m

Write one use for each. [CBSE (AI) 2017]

Ans. (a) X-rays: Used as a diagnostic tool in medicine and as a treatment for certain forms of cancer.

(b) Microwaves: Used in radar systems for aircraft navigation.

Q. 9. Identify the electromagnetic waves whose wavelengths lie in the range

(a) 10^{-11}m < λ < 10^{-8} m

(b) 10^{-4} m < λ < 10^{-1} m

Write one use of each. **[CBSE (AI) 2017]**

Ans. (a) X-rays / Gamma rays

(b) Infrared / Visible rays / Microwaves

(i) X-rays are used as a diagnostic tool in medicine.

(ii) Gamma rays are used in medicine to destroy cancer cells.

(iii) Infrared are used in green houses to warm plants.

(iv) Visible rays provide us information about the world.

(v) Microwaves are used in RADAR system for aircraft navigation.

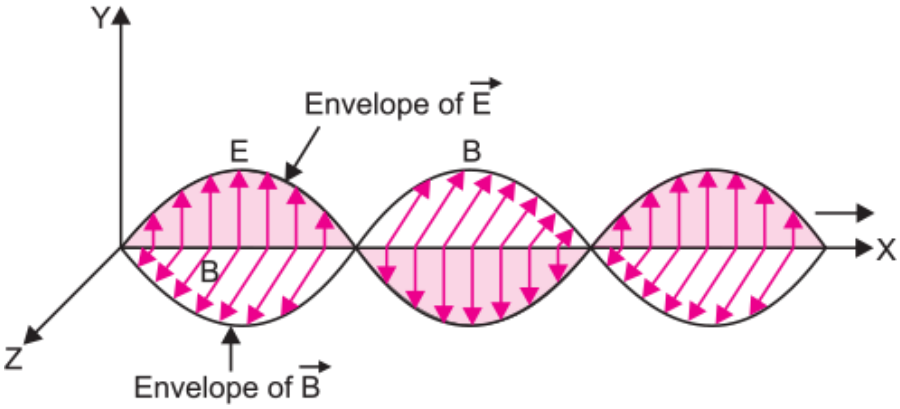
Short Answer Questions – I (OIQ)

Q. 1. What is meant by the transverse nature of electromagnetic waves? Draw a diagram showing the propagation of an electromagnetic wave along X-direction, indicating clearly the directions of oscillating electric and magnetic fields associated with it.

Ans. Transverse Nature of Electromagnetic Waves :

In an electromagnetic wave, the electric and magnetic field vectors oscillate, perpendicular to the direction of propagation of wave. This is called transverse nature of electromagnetic wave.

In an electromagnetic wave, the three vectors $\rightarrow_{E}, \rightarrow_{B}$ and $\rightarrow_{K}$ form a right handed system. Accordingly if a wave is propagating along X-axis, the electric field vector oscillates along Y-axis and magnetic field vector oscillates along Z-axis. Diagram is shown in figure.



Q. 2. What do electromagnetic waves consist of ? Explain on what factors does its velocity in vacuum depend?

Ans. Electromagnetic waves consist of mutually perpendicular electric and magnetic field vectors. Its velocity in vacuum is given by

$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ is same for all electromagnetic waves.

In other words its velocity in vacuum does not depend on any factor.

Q. 3. A plane electromagnetic wave travels in vacuum, along the Y-direction. Write down the

(i) ratio of the magnitudes and
(ii) the direction, of its electric and magnetic field vectors.

Ans. (i) $\frac{B}{E}$ = speed of light (c = 3 × 10^8 m/s)

(ii) $\vec{K}, \vec{E}, \vec{B}$ form a right handed system. As wave propagation vector ($\vec{K}$) is along Y-axis; electric field ($\vec{E}$) must be along Z-axis and magnetic field $\vec{B}$ along X-axis.

Q. 4. When can a charge act as a source of electromagnetic wave? How are the directions of electric and magnetic field vectors, in an electromagnetic wave related to each other and to the direction of propagation of the wave?

Which physical quantity, if any, has the same value for waves belonging to the different parts of the electromagnetic spectrum?

Ans. Source of Electromagnetic Waves: The source of electromagnetic waves is an accelerated (or decelerated) charge or an oscillating LC circuit. In an electromagnetic wave, the electric field vector $\vec{E}$ and magnetic field vector $\vec{B}$ are mutually perpendicular and also perpendicular to direction of wave propagation such that wave propagation vector $\vec{K}$, electric field vector $\vec{E}$ and magnetic field vector $\vec{B}$ form a right handed orthogonal system.

The speed of waves in vacuum is the same for different parts of electromagnetic spectrum.

Q. 5. To which regions of the electromagnetic spectrum, the following wavelengths belong? 2,000 Å, 5,000 Å, 10,000 Å and 1.0 Å.

Ans. 2,000 Å — Ultraviolet radiation 5,000 Å — Visible light

10,000 Å — Infrared radiation 1.0 Å — X-rays

Q. 6. Write the following in descending order of wavelength:

Gamma rays, Hertzian waves, yellow light, blue light, infrared radiation, ultraviolet radiation, X-rays, γ–rays.

Ans. Hertzian waves, infrared radiation, yellow light, blue light, ultraviolet radiation, X-rays, γ–rays.

Q. 7. Find the wavelength of electromagnetic waves of frequency 5× 1019 Hz in free space. Give its two applications.

Ans.

$$\text{Wavelength, } \lambda = \frac{c}{\nu} = \frac{3\times10^{8}}{5\times10^{19}} = 6 \times 10^{-12} m$$

These are gamma rays.

These are used for : (i) Nuclear reactions (ii) Radiotherapy.

Q. 8. Find the wavelength of electromagnetic waves of frequency 4 × 109 Hz in free space. Give its two applications.

Ans.

$$\text{Wavelength, } \lambda = \frac{c}{\nu} = \frac{3\times10^{8}}{4\times10^{9}} = \frac{3}{40}\ m = \frac{300}{40}\ \text{cm} = 7.5\ \text{cm}.$$

This wavelength corresponds to microwave region (or short radio waves).

These are used in (i) RADAR (ii) Microwave ovens.

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.