IMPORTANT QUESTIONS CLASS – 12 PHYSICS CHAPTER – 8 ELECTROMAGNETIC WAVES

Question 1.
Answer the following:
(a) Name the em waves which are used for the treatment of certain forms of cancer. Write their frequency range.
Answer:
Gamma rays.
Frequency range > 3×10^{20} Hz

(b) Thin ozone layer on top of the stratosphere is crucial for human survival. Why?
Answer:
The thin ozone layer on top of the stratosphere is crucial for human survival because it absorbs most of the ultraviolet rays coming from the sun. If the ozone layer had not been there, then ultraviolet rays would have entered the earth and caused danger to the survival of the human race.

(c) An em wave exerts pressure on the surface on which it is incident. Justify. (CBSE Delhi 2014)
Answer:
An em wave carries a linear momentum with it. The linear momentum carried by a portion of a wave having energy U is given by p = U/c.

Thus, if the wave incident on a material surface is completely absorbed, it delivers energy U and momentum p = U/c to the surface. If the wave is totally reflected, the momentum delivered is p = 2U/c because the momentum of the wave changes from p to – p. Therefore, it follows that an em wave incident on a surface exerts a force and hence a pressure on the surface.

Question 2.
Answer the following questions:
(a) Why is the thin ozone layer at the top of the stratosphere crucial for human survival? Identify to which part of the electromagnetic spectrum does this radiation belongs and write one important application of the radiation.
Answer:
The thin ozone layer on top of the stratosphere is crucial for human survival because it

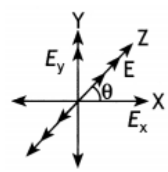
absorbs most of the ultraviolet rays coming from the sun. If the ozone layer had not been there, then ultraviolet rays would have entered the earth and caused danger to the survival of the human race. This radiation is UV radiation. It is used in sterilization.

(b) Why are infrared waves referred to as heat rays? How are they produced? What role do they play in maintaining the earth's warmth through the greenhouse effect?
Answer:
Infrared radiations heat up the material on which they fall, hence they are also called heat rays. They are produced by the vibration of atoms and molecules. After falling on the earth, they are reflected back into the earth's atmosphere. The earth's atmosphere does not allow these radiations to pass through as such they heat up the earth's atmosphere.

Question 3.
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.
Answer:
Electromagnetic waves are produced by accelerated charges which produce an oscillating electric field and magnetic field (which regenerate each other).

- Source of the Energy: Energy of the accelerated charge or the source that accelerates the charges.
- Expression: $E_x = E_o \sin (kz - \omega t)$ and $B_y = B_o \sin (kz - \omega t)$
  (a) They are transverse in nature.
  (b) They don't require a medium to propagate.

Question 4.
How are em waves produced by oscillating charges?
Draw a sketch of linearly polarised em waves propagating in the Z-direction. Indicate the directions of the oscillating electric and magnetic fields.
Answer:
(a) 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.
(b) See Figure.



Question 5.
Write Maxwell's generalization of Ampere's Circuital Law. Show that in the process of charging a capacitor, the current produced within the plates of the capacitor is i = ε_odϕEdt where ΦE is the electric flux produced during charging

of the capacitor plates.
Answer:
The generalized form of Maxwell ampere law is
B dl→= μ_o(l + l_D) where l_D = ε_odϕEdt=dqdt

The electric flux Φ between the plates of the parallel plate capacitor through which a time-dependent current flow is given by:
Φ_E = E A, but E = σ/ε_o
Therefore we have

$$\phi_E = \frac{\sigma A}{\varepsilon_0} = \frac{q}{\varepsilon_0}$$

$$\text{Now } i = \frac{dq}{dt} = \frac{d\phi_E \varepsilon_0}{dt} = \varepsilon_0 \frac{d\phi_E}{dt}$$

Question 6.
(a) Why are Infrared waves often called heatwaves? Explain.
Answer:
Infrared waves have frequencies lower than those of visibLe
Light; they have the ability to vibrate not only the electrons but the entire atoms or molecules of a body. This vibration increases the internal energy and temperature of the body. That is why infrared waves are often called heat waves.

(b) What do you understand by the statement, “Electromagnetic waves transport momentum”? (CBSE AI, Delhi 2018)
Answer:
If we consider a plane perpendicular to the direction of propagation of the electromagnetic wave, then electric charges present on the plane will be set and sustained in motion by the electric and magnetic fields of the electromagnetic wave. The charges present on the surface thus acquire energy and momentum from the waves. This just illustrates the fact that an electromagnetic wave (like other waves) transfers energy and momentum.

Question 7.
(a) When the oscillating electric and magnetic fields are along the x- and y-direction respectively
(i) point out the direction of propagation of the electromagnetic wave,
Answer:
Z-axis

(ii) express the velocity of propagation in terms of the amplitudes of the oscillating electric and magnetic fields.
Answer:
$c = E_o / B_o$

(b) How do you show that the em wave carries energy and momentum? (CBSE A! 2013C)
Answer:
Consider a plane perpendicular to the direction of propagation of the electromagnetic wave. If there are, on this plane, electric charges, they will be set and sustained in motion by the electric and magnetic fields of the electromagnetic wave. The charges thus acquire energy and momentum from the waves. This illustrates the fact that an electromagnetic wave carries energy and momentum.

Question 8.
A radio can tune In to any station in the 7.5 MHz to 12 MHz bands. What is the corresponding wavelength band? (NCERT)
Answer:

Given $\nu_1 = 7.5$ MHz $= 7.5 \times 10^6$ Hz
$n_2 = 12$ MHz $= 12 \times 10^6$ Hz
Using the relation $\lambda = \frac{c}{\nu}$ we have

(a) $\lambda_1 = \frac{c}{\nu_1} = \frac{3 \times 10^8}{7.5 \times 10^6} = 40$ m

(b) $\lambda_2 = \frac{c}{\nu_2} = \frac{3 \times 10^8}{12 \times 10^6} = 25$ m

Thus the wavelength band is 40 m to 25m.

Question 9.
Suppose that the electric field amplitude of an electromagnetic wave $E_0 = 120$ N C^{-1} and that Its frequency is v = 50.0 MHz. (a) Determine, B0, ω k, and λ. (b) Find expressions for E and B. (NCERT)
Answer:

Given $E_0 = 120$ N C^{-1},
$\nu = 50.0$ MHz $= 50 \times 10^6$ Hz,

(a) $B_0 = \frac{E_0}{c} = \frac{120}{3 \times 10^8} = 4 \times 10^{-7}$ T $= 400$ nT

(b) $\omega = 2\pi\nu = 2 \times 3.14 \times 50 \times 10^6$
$= 3.14 \times 10^8$ rad s^{-1}

(c)
$k = \frac{2\pi}{\lambda} = \frac{2\pi\nu}{c} = \frac{3.14 \times 10^8}{3 \times 10^8} = 1.047$ rad m^{-1}

(d) $\lambda = \frac{2\pi}{k} = \frac{2 \times 3.14}{1.047} = 6$ m

Question 10.
In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude 48 V m^{-1}.
(a) What is the wavelength of the wave?
(b) What is the amplitude of the oscillating magnetic field?
(c) Show that the average energy density of the E field equals the average energy density of the 8 fields.
[c = $3 \times 10^8 ms^{-1}$.]
Answer:

(c) The average density of electric field is
given by $U_e = 12\varepsilon_0 E^2$ and the average energy density of the magnetic field is given by

U_B = B22μ0. But B = Ec and C = 1μ0ε0√ , hence the above equation becomes UB = B22μ0=E22μ0c2,

Given $n = 2.0 \times 10^{10}$ Hz, $E_0 = 48$ V m^{-1}

(*a*) $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{2.0 \times 10^{10}} = 1.5 \times 10^{-2}$ m

(*b*) $B_0 = \frac{E_0}{c} = \frac{48}{3 \times 10^8} = 1.6 \times 10^{-7}$ T

$$U_B = \frac{E^2}{2\mu_0 \times \frac{1}{\mu_0 \varepsilon_0}} = \frac{1}{2}\varepsilon_0 E^2 = U_e .$$