CBSE Test Paper-02

Class - 12 Physics (Electromagnetic waves)

1. Infrared waves are produced by
   a. permanent magnets
   b. dipole oscillations
   c. all hot bodies and molecules
   d. static charges
2. Which of these mechanisms can be used to produce electromagnetic waves?
   a. stationary point charge
   b. point charge oscillating in simple harmonic motion
   c. point charge travelling in a straight line with constant velocity
   d. point charge drifting slowly
3. Calculate the frequency of red light with a wavelength of 4.2×10^{-7} m
   a. 7.14×10^{14}Hz
   b. 7.34×10^{14}Hz
   c. 7.64×10^{14}Hz
   d. 7.94×10^{14}Hz
4. How much time does it take light to travel from the moon to the earth, a distance of 384,000 km?
   a. 1.48 s
   b. 1.58 s
   c. 1.28 s
   d. 1.38 s
5. Infrared waves are sometimes referred to as heat waves because
   a. water molecules present in most materials readily reflect infrared waves
   b. water molecules present in most materials readily transmit infrared waves
   c. water molecules present in most materials readily absorb infrared waves
   d. water molecules present in most materials readily reradiate infrared waves
6. It is necessary to use satellites for long distance TV transmission. Why?
7. Name the electromagnetic radiation which can be produced by a klystron or a magnetron valve.

8. Name the EM waves used for studying crystal structure of solids. What is its frequency range?

9. A radio can tune in to any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?

10. Name the electromagnetic radiations having the wavelength range from 1 nm to 10^{-3}nm. Give its two important applications.

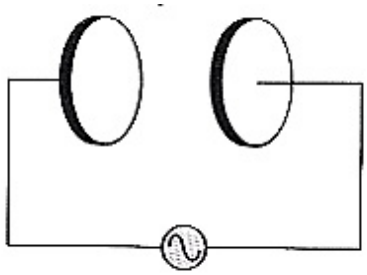
11. The oscillating electric field of an electromagnetic wave is given by:
$E_y = 30 \sin\left[2 \times 10^{11} t + 300\pi x\right] Vm^{-1}$

    a. Obtain the value of the wavelength of the electromagnetic wave.
    b. Write down the expression for the oscillating magnetic field.

12. Write any four characteristics of electromagnetic waves. Give two uses of (i) radio waves (ii) Microwaves.

13. Why sky wave propagation of electromagnetic waves cannot be used for TV transmission? Suggest two methods by which range of TV transmission can be increased.

14. A parallel plate capacitor made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad s^{-1}.



    a. What is the rms value of the conduction current?
    b. Determine the amplitude of B at a point 3.0 cm from the axis between the plates.

15. Find the amplitude of the electric field in a parallel beam of light of intensity 7.0 W/m^2.

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Answers

1. c. all hot bodies and molecules
   Explanation: When an object gets heated, it gains energy as a result of which the atoms or molecules move or vibrate and radiate infrared waves.
2. b. point charge oscillating in simple harmonic motion
   Explanation: This charge produces an oscillating electric field in its neighbourhood. This field in turn, produces an oscillating magnetic field in its neighbourhood. The process continues as both the fields acts as source of each other. Hence, an em wave originates from the oscillating charge.
   Note: The frequency of em wave is equal to frequency of oscillating charge.
3. a. 7.14
   Explanation: $\nu = \frac{c}{\lambda} = \frac{3\times10^8}{4.2\times10^-7} = 7.14 \times 10^{14} Hz$
4. c. 1.28 s
   Explanation: $time = \frac{distance}{speed} = \frac{384000\times1000m}{3\times10^8} = 1.28s$
5. c. water molecules present in most materials readily absorb infrared waves
   Explanation: water molecules and also (CO_2 and NH_3 molecules) present in most materials readily absorb infrared waves, increases the thermal motions and heat up the materials and their surroundings.
6. It is so because television signals are not properly reflected by the ionosphere. Therefore for reflection of signals, satellites are needed.
7. Electromagnetic wave which is produced by klystron or a magnetron valve is microwaves which has an application in microwave oven for cooking.
8. X-rays are used for studying crystals structure of solids. Their frequency range is 10^{16} Hz to $3 \times 10^{21} Hz$.
9. $\lambda_1 = \frac{c}{\nu_1} = \frac{3\times10^8}{7.5\times10^6} = 40m$
   $\lambda_2 = \frac{c}{\nu_2} = \frac{3\times10^8}{12\times10^6}$ = 25 m
   Hence, the wavelength band is 40m - 25m

10. X-rays have the wavelength between 1 nm and 10^{-3} nm.
    Uses of X-rays

    a. In medical diagnosis, as they can pass through the muscles but not through the bones(using of soft X-ray), hard X-rays are used in chemotherapy or radiotherapy.
    b. In detecting faults, cracks, etc. in metal products, huge bridges etc.

11. $E_y = 30 \sin\left[2 \times 10^{11} t + 300\pi x\right] Vm^{-1}$

    a. $K = 300\pi = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{1}{150} = 6.7 \times 10^{-3} m$
    b. $B_z = (10^{-7}) \sin\left[2 \times 10^{11} t + 300\pi x\right] T$

12. Characteristics of electromagnetic waves:

    i. Electromagnetic waves are produced by accelerating or oscillating charge.
    ii. E.M. waves do not require any material medium for their propagation.
    iii. E.M. waves travel in free space with a velocity $C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ which is equal to the velocity of light $(c = 3 \times 10^8 m/s)$.
    iv. E.M. waves are transverse in nature.

    Uses of Radio waves:

    i. They are used in radio and TV communication systems.
    ii. Cellular phones use radio waves to transmit voice communication in the ultrahigh frequency (UHF) band.

    Uses of Microwaves:

    i. Microwaves are used in Radar systems for aircraft navigation.
    ii. Microwave ovens are used for cooking purposes.

13. Sky waves have frequencies of 100 - 200 MHz, which penetrate ionosphere (frequencies > 30 MHz cannot be used), hence it cannot be used for TV transmission. Two methods by which range of TV transmission can be increased:
    (a) use of tall antenna
    (b) use of repeaters between transmitters and receivers (line-of-sight transmission).

14. a. Here, a = 6.0 cm

C = 100 pF = $100 \times 10^{-12} F$

$\omega = 300\ rads^{-1}$

E_{rms} = 230V

$I_{rms} = \frac{E_{rms}}{X_C} = \frac{E_{rms}}{\frac{1}{\omega C}} = E_{rms} \times \omega C$

$\therefore I_{rms} = 230 \times 300 \times 100 \times 10^{-12}$

$= 6.9 \times 10^{-6} A = 6.9 \mu A$

b. Since,I = I_D whether I is steady d.c. or a.c. This is shown below:

$I_D = \varepsilon_0 \frac{d(\phi_E)}{dt} = \varepsilon_0 \frac{d}{dt}(EA) (\because \phi_E = EA)$

Or $I_D = \varepsilon_0 A \frac{dE}{dt}$

$= \varepsilon_0 A \frac{d}{dt}\left(\frac{Q}{\varepsilon_0 A}\right) \left(\because E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}\right)$

$I_D = \varepsilon_0 A \times \frac{1}{\varepsilon_0 A} \frac{dQ}{dt} = \frac{dQ}{dt} = I$

We know that

$B = \frac{\mu_0}{2\pi} \frac{r}{R^2} I_D$

This formula goes through even if I_D (and therefore B) oscillates in time. The formula shows that they oscillate in phase.

Since I_D = I, we have $B = \frac{\mu_0 r I}{2\pi R^2}$

If I = I_0, the maximum value of current, then amplitude of B = maximum value of B

$= \frac{\mu_0 r I_0}{2\pi R^2} = \frac{\mu_0 r \sqrt{2}\ I_{rms}}{2\pi R^2} \left(\because I_0 = \sqrt{2}\ I_{rms}\right)$

$= \frac{4\pi \times 10^{-7} \times 0.03 \times \sqrt{2} \times 6.9 \times 10^{-6}}{2 \times 3.14 \times (0.06)^2} T$

$= 1.63 \times 10^{-11} T$

15. The intensity of plane electromagnetic wave is given by:

$I = U_{av^C} = \frac{1}{2} \varepsilon_0 E_0^2 c$

or $E_0 = \left(\frac{2I}{\varepsilon_0 c}\right)^{1/2}$

or $E_0 = \left[\frac{2 \times 8.0}{(8.85 \times 10^{-12}) \times (3 \times 10^8)}\right]^{1/2}$

= 77.6 NC^{-1}