



Chapter 8 : Electromagnetic Waves (50 Important MCQs)

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Notes

50 important MCQs from GSEB, CBSE, NEET and JEE exams · Answer key at the end

Section A — Multiple Choice Questions

Each question carries 1 mark. Choose the correct option.

Q.1 The relative permittivity of a non-magnetic medium is 4. When electromagnetic waves of frequency 3 MHz pass from vacuum into this medium,

- (A) λ doubles, ν remains constant
(B) λ doubles, ν becomes half
(C) λ becomes half, ν remains constant
(D) λ and ν both remain constant

Q.2 For a wave propagating in vacuum, the electric field $\vec{E}$ and magnetic field $\vec{B}$ are perpendicular to each other. If the direction of propagation is $\hat{k}$ and the direction of polarisation is $\vec{X}$, then

- (A) $\vec{X} \parallel \vec{B}, \hat{k} \parallel \vec{B} \times \vec{E}$ (B) $\vec{X} \parallel \vec{E}, \hat{k} \parallel \vec{E} \times \vec{B}$ (C) $\vec{X} \parallel \vec{B}, \hat{k} \parallel \vec{E} \times \vec{B}$ (D) $\vec{X} \parallel \vec{E}, \hat{k} \parallel \vec{B} \times \vec{E}$

Q.3 The maximum value of the magnetic field of a progressive electromagnetic wave is 20 nT. The maximum value of the electric field is

- (A) 12 V/m (B) 3 V/m (C) 6 V/m (D) 9 V/m

Q.4 Match List-I (type of wave) with List-II (association/application):

(a) Infrared waves — (i) to treat muscular strain; (b) Radio waves — (ii) for broadcasting; (c) X-rays — (iii) to detect fracture of bones; (d) Ultraviolet rays — (iv) absorbed by the ozone layer.

Choose the correct matching:

- (A) a-iii, b-ii, c-i, d-iv
(B) a-i, b-ii, c-iii, d-iv
(C) a-iv, b-iii, c-ii, d-i
(D) a-i, b-ii, c-iv, d-iii

Q.5 For an electromagnetic wave propagating in the +z-direction, which of the following combinations gives the directions of $\vec{E}$ and $\vec{B}$ respectively?

- (A) $(2\hat{i} + 3\hat{j})$ and $(\hat{i} + 2\hat{j})$
(B) $(-2\hat{i} - 3\hat{j})$ and $(3\hat{i} - 2\hat{j})$
(C) $(3\hat{i} + 4\hat{j})$ and $(4\hat{i} - 3\hat{j})$
(D) $(\hat{i} + 2\hat{j})$ and $(2\hat{i} - \hat{j})$

Q.6 Arrange the following radiations in order of increasing energy per quantum: A — blue light, B — yellow light, C — X-ray, D — radio wave.

- (A) D, B, A, C (B) A, B, D, C (C) C, A, B, D (D) B, A, D, C

Q.7 An EM wave from air enters a medium. The electric fields are $\vec{E}_1 = E_{01}\hat{x} \cos \left[2\pi\nu \left(\frac{z}{c} - t \right) \right]$ in air and $\vec{E}_2 = E_{02}\hat{x} \cos [k(2z - ct)]$ in the medium, where k and ν refer to their values in air. The medium is non-

magnetic. If ϵ_{r1} and ϵ_{r2} are the relative permittivities of air and the medium, then

- (A) $\frac{\epsilon_{r1}}{\epsilon_{r2}} = 4$ (B) $\frac{\epsilon_{r1}}{\epsilon_{r2}} = 2$ (C) $\frac{\epsilon_{r1}}{\epsilon_{r2}} = \frac{1}{4}$ (D) $\frac{\epsilon_{r1}}{\epsilon_{r2}} = \frac{1}{2}$

Q.8 The magnetic field of a wave is $\vec{B} = 3 \times 10^{-8} \sin (\omega t - kx + \phi) \hat{j}$ T. The appropriate equation for the electric field is

- (A) $3 \times 10^{-9} \sin (\omega t - kx + \phi) \hat{k}$ (B) $9 \sin (\omega t - kx + \phi) \hat{k}$
(C) $16 \times 10^{-9} \sin (\omega t - kx + \phi) \hat{k}$ (D) $20 \times 10^{-9} \sin (\omega t - kx + \phi) \hat{k}$

Q.9 Choose the correct relation between the wavelengths of different parts of the electromagnetic spectrum:

- (A) $\lambda_{radio} > \lambda_{micro} > \lambda_{visible} > \lambda_{x-rays}$ (B) $\lambda_{visible} > \lambda_{micro} > \lambda_{radio} > \lambda_{x-rays}$
(C) $\lambda_{visible} > \lambda_{x-rays} > \lambda_{radio} > \lambda_{micro}$ (D) $\lambda_{x-rays} > \lambda_{micro} > \lambda_{radio} > \lambda_{visible}$

Q.10 An electromagnetic wave of 100 MHz travels in the +x direction. At an instant, the magnetic field at the origin is $2 \times 10^{-8} \hat{k}$ T. The electric field (in V/m) at the origin at the same instant is

- (A) $0.6\hat{j}$ (B) $6\hat{j}$ (C) $0.6\hat{k}$ (D) $6\hat{k}$

Q.11 The electric field of a plane electromagnetic wave in a non-magnetic medium is $E = 20 \cos (2 \times 10^{10}t - 200x)$ V/m. The dielectric constant of the medium is ($\mu_r = 1$)

- (A) $\frac{1}{3}$ (B) 3 (C) 2 (D) 9

Q.12 An electric bulb is rated 200 W. Treating it as a point source with 3.5% efficiency, the peak magnetic field at 4 m from the bulb is

- (A) 1.19×10^{-8} T (B) 1.71×10^{-8} T (C) 0.84×10^{-8} T (D) 3.36×10^{-8} T

Q.13 A light wave travelling in air along the x-direction is $E_y = 540 \sin \pi \times 10^4 (x - ct)$ V m⁻¹. The peak value of the magnetic field is ($c = 3 \times 10^8$ m s⁻¹)

- (A) 18×10^{-7} T (B) 54×10^{-7} T (C) 54×10^{-8} T (D) 18×10^{-8} T

Q.14 Match the electromagnetic waves with their wavelength ranges:

(a) Microwave — (1) 400 nm to 1 nm; (b) Ultraviolet — (2) 1 nm to 10^{-3} nm; (c) X-ray — (3) 1 mm to 700 nm; (d) Infrared — (4) 0.1 m to 1 mm.

- (A) a-1, b-4, c-2, d-3 (B) a-4, b-1, c-2, d-3
(C) a-4, b-2, c-1, d-3 (D) a-4, b-1, c-3, d-2

Q.15 Match the laws with their equations:

(a) Gauss's law for electricity — (1) $\oint \vec{E} \cdot d\vec{l} = -\frac{d\phi_B}{dt}$; (b) Faraday's law — (2) $\oint \vec{B} \cdot d\vec{A} = 0$; (c) Gauss's law for magnetism — (3) $\oint \vec{B} \cdot d\vec{l} = \mu_0 i_c + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$; (d) Ampere-Maxwell law — (4) $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$.

- (A) a-4, b-1, c-2, d-3 (B) a-1, b-2, c-3, d-4
(C) a-3, b-4, c-1, d-2 (D) a-2, b-3, c-4, d-1

Q.16 The electric and magnetic field components of an electromagnetic wave in vacuum are

$E_x = E_0 \sin (kz - \omega t)$ and $B_y = B_0 \sin (kz - \omega t)$. The correct relation between E_0 and B_0 is

- (A) $kE_0 = \omega B_0$ (B) $E_0 B_0 = \omega k$ (C) $\omega E_0 = kB_0$ (D) $E_0 = kB_0$

Q.17 An electromagnetic wave is given by $E = 200 \sin (1.5x - 4.5 \times 10^8 t)$ N/C. If the (average) energy density of the wave is $N \times 10^{-8}$ J/m³, then N is ($\epsilon_0 = 9 \times 10^{-12}$ SI units)

- (A) 9 (B) 18 (C) 36 (D) 72

Q.18 An electromagnetic wave has electric field $\vec{E} = 9.6 \hat{j} \sin \left[2\pi \left(30 \times 10^6 t - \frac{x}{10} \right) \right]$ (SI units). The maximum magnetic field is

- (A) 3.2×10^{-8} T (B) 9.6×10^{-8} T (C) 1.7×10^{-8} T (D) 10^{-7} T

Q.19 Calculate the average energy density of an electromagnetic wave whose electric field oscillates with amplitude 50 V/m and frequency 5×10^{10} Hz.

- (A) 2×10^{-6} J/m³ (B) 1.1×10^{-8} J/m³ (C) 3×10^{-7} J/m³ (D) 1.6×10^{-7} J/m³

Q.20 An alternating voltage of amplitude 40 V and frequency 4 kHz is applied directly across a capacitor of 12 μ F. The maximum displacement current between the plates is nearly

- (A) 13 A (B) 8 A (C) 10 A (D) 12 A

Q.21 The frequency order for γ -rays (b), X-rays (a) and UV rays (c) is

- (A) $b > a > c$ (B) $a > b > c$ (C) $c > b > a$ (D) $a > c > b$

Q.22 The electric field of an electromagnetic wave in vacuum is $\vec{E} = 40 \cos (kz - 6 \times 10^8 t) \hat{i}$ (SI units). The value of the wave number k is

- (A) 2 m^{-1} (B) 0.5 m^{-1} (C) 6 m^{-1} (D) 3 m^{-1}

Q.23 The electric field of an electromagnetic wave in a medium is $E_x = 0$, $E_y = 2.5 \cos (2\pi \times 10^6 t - \pi \times 10^{-2} x)$, $E_z = 0$. This wave

- (A) moves in the x-direction with frequency 10^6 Hz and wavelength 100 m
 (B) moves in the x-direction with frequency 10^6 Hz and wavelength 200 m
 (C) moves in the -x direction with frequency 10^6 Hz and wavelength 200 m
 (D) moves in the y-direction with frequency $2\pi \times 10^6$ Hz and wavelength 200 m

Q.24 An electromagnetic wave propagating in the +z-direction is represented by

- (A) $\vec{E} = E_0 \hat{i}, \vec{B} = B_0 \hat{j}$ (B) $\vec{E} = E_0 \hat{k}, \vec{B} = B_0 \hat{i}$ (C) $\vec{E} = E_0 \hat{j}, \vec{B} = B_0 \hat{i}$ (D) $\vec{E} = E_0 \hat{j}, \vec{B} = B_0 \hat{k}$

Q.25 How does a microwave oven cook food containing water?

- (A) Microwaves are heat waves, so they always produce heat.
 (B) In a microwave oven, infrared waves produce heat.
 (C) The frequency of the microwaves has no relation with the natural frequency of water molecules.
 (D) The frequency of the microwaves is matched to the resonant frequency of water molecules.

Q.26 Radiation of intensity $25 \times 10^4 \text{ W/m}^2$ is incident normally on a perfectly reflecting surface of area 15 cm^2 . The average force on the surface is

- (A) $1.25 \times 10^{-6} \text{ N}$ (B) $2.50 \times 10^{-6} \text{ N}$ (C) $1.20 \times 10^{-6} \text{ N}$ (D) $3.0 \times 10^{-6} \text{ N}$

Q.27 Radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (c = speed of light)

- (A) $\frac{E}{c}$ (B) $\frac{2E}{c}$ (C) $\frac{2E}{c^2}$ (D) $\frac{E}{c^2}$

Q.28 The energy of one photon of a radiation is 15 keV. This radiation belongs to which part of the electromagnetic spectrum?

- (A) ultraviolet (B) gamma rays (C) X-rays (D) infrared

Q.29 An electromagnetic wave propagates in vacuum. The rms value of its electric field is 6 V m^{-1} . The maximum value of its magnetic field is

- (A) $2.83 \times 10^{-8} \text{ T}$ (B) $0.70 \times 10^{-8} \text{ T}$ (C) $4.23 \times 10^{-8} \text{ T}$ (D) $1.41 \times 10^{-8} \text{ T}$

Q.30 An em wave propagates in a medium with velocity $\vec{v} = v\hat{i}$. Its instantaneous oscillating electric field is along +y. The oscillating magnetic field is along

- (A) -x (B) -z (C) -y (D) +z

Q.31 A 20 μF capacitor is being charged by a constant voltage source. When the p.d. across it changes at a rate of 3 V/s, find the conduction current in the connecting wires and the displacement current between the plates.

- (A) 0, 0 (B) 0, 60 μA (C) 60 μA , 60 μA (D) 60 μA , 0

Q.32 The ratio of the contributions made by the electric field and magnetic field components to the intensity of an electromagnetic wave is

- (A) 1 : 1 (B) 1 : c (C) 1 : c^2 (D) c : 1

Q.33 For a plane electromagnetic wave propagating in the +x-direction, which combination gives the possible directions of $\vec{E}$ and $\vec{B}$ respectively?

- (A) $-\hat{j} + \hat{k}, -\hat{j} + \hat{k}$ (B) $\hat{j} + \hat{k}, \hat{j} + \hat{k}$
(C) $-\hat{j} + \hat{k}, -\hat{j} - \hat{k}$ (D) $\hat{j} + \hat{k}, -\hat{j} - \hat{k}$

Q.34 A capacitor C is connected across an a.c. source $V = V_0 \sin \omega t$. The displacement current between the plates is

- (A) $I_d = V_0 \omega C \sin \omega t$ (B) $I_d = V_0 \omega C \cos \omega t$ (C) $I_d = \frac{V_0}{\omega C} \cos \omega t$ (D) $I_d = \frac{V_0}{\omega C} \sin \omega t$

Q.35 Match the electromagnetic waves with their typical wavelengths:

(a) AM radio waves — (i) 10^{-10} m; (b) Microwaves — (ii) 10^2 m; (c) Infrared radiation — (iii) 10^{-2} m; (d) X-rays — (iv) 10^{-4} m.

- (A) a-iii, b-iv, c-ii, d-i (B) a-ii, b-iii, c-iv, d-i
(C) a-iv, b-iii, c-ii, d-i (D) a-iii, b-ii, c-i, d-iv

Q.36 When light propagates through a material medium of relative permittivity ϵ_r and relative permeability μ_r , its velocity is (c = velocity of light in vacuum)

- (A) $\sqrt{\frac{\epsilon_r}{\mu_r}}$ (B) $\frac{c}{\sqrt{\epsilon_r \mu_r}}$ (C) c (D) $\sqrt{\frac{\mu_r}{\epsilon_r}}$

Q.37 In a plane electromagnetic wave in free space, the electric field oscillates at 2.0×10^{10} Hz with amplitude 48 V m^{-1} . The amplitude of the oscillating magnetic field is

- (A) 1.6×10^{-6} T (B) 1.6×10^{-9} T (C) 1.6×10^{-8} T (D) 1.6×10^{-7} T

Q.38 An a.c. source is connected to a capacitor C. If the operating frequency decreases,

- (A) the capacitive reactance remains constant (B) the capacitive reactance decreases
(C) the displacement current increases (D) the displacement current decreases

Q.39 A parallel plate capacitor is charged by connecting it to a battery through a resistor. If I is the current in the circuit, then in the gap between the plates

- (A) a displacement current of magnitude I flows opposite to I
(B) a displacement current greater than I flows in any direction
(C) there is no current
(D) a displacement current of magnitude I flows in the same direction as I

Q.40 Which is **not** a property of an electromagnetic wave travelling in free space?

- (A) They travel with a speed equal to $1/\sqrt{\mu_0 \epsilon_0}$.
(B) They originate from charges moving with uniform speed.

(C) They are transverse in nature.

(D) The energy density in the electric field equals that in the magnetic field.

Q.41 The speed of electromagnetic waves in vacuum is 3×10^8 m/s. Radio waves of wavelength 150 m have a frequency of

- (A) 20 kHz (B) 45 MHz (C) 2 kHz (D) 2 MHz

Q.42 When electromagnetic waves of intensity I are incident on an opaque, non-reflecting (perfectly absorbing) surface, the pressure exerted on it is

- (A) Ic (B) Ic^2 (C) $\frac{I}{c}$ (D) $\frac{I}{c^2}$

Q.43 The dimensional formula of $\mu_0 \epsilon_0$ is

- (A) $[M^0 L^{-2} T^2]$ (B) $[M^0 L^2 T^{-2}]$ (C) $[M^0 L^1 T^{-1}]$ (D) $[M^0 L^{-1} T^1]$

Q.44 A plane electromagnetic wave of frequency 25 MHz travels in free space along the +x-direction. At a particular point and time, $\vec{B} = 2.1 \times 10^{-8} \hat{k}$ T. Find $\vec{E}$ at this point.

- (A) $-2.1\hat{j}$ V/m (B) $4.2\hat{j}$ V/m (C) $6.3\hat{j}$ V/m (D) $-3.2\hat{j}$ V/m

Q.45 A radio can tune into any station in the 6 MHz to 12 MHz band. The corresponding wavelength band is ($c = 3 \times 10^8$ m/s)

- (A) 20 m to 30 m (B) 25 m to 50 m (C) 40 m to 60 m (D) 10 m to 20 m

Q.46 A charged particle oscillates about its mean position with a frequency of 10^9 Hz. The frequency of the electromagnetic waves produced is

- (A) 10^{-9} Hz (B) 10^9 Hz (C) 10^{18} Hz (D) 10^{10} Hz

Q.47 Which one of the following is the frequency range of the AM (amplitude modulated) band?

- (A) 530 Hz to 1710 Hz (B) 530 kHz to 1710 kHz
(C) 2300 kHz to 2700 kHz (D) 23 MHz to 27 MHz

Q.48 The magnitudes of the electric and magnetic fields in an electromagnetic wave are related by

- (A) $B_0 = \frac{E_0}{c}$ (B) $E_0 = \frac{B_0}{c}$ (C) $E_0 = \frac{B_0^2}{2c}$ (D) $B_0 = \frac{E_0^2}{2c}$

Q.49 Light of total energy 6.48×10^5 J is incident normally on a non-reflecting surface. The momentum imparted to the surface is ____ N s.

- (A) 1.26×10^{-3} (B) 6.21×10^{-3} (C) 21.6×10^{-3} (D) 2.16×10^{-3}

Q.50 The amplitude of the magnetic field of an electromagnetic wave is 510 nT. The amplitude of its electric field is ____ V m⁻¹.

- (A) 153 (B) 1.7×10^{-6} (C) 1.53×10^{-7} (D) 170

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	11	D	21	A	31	C	41	D
2	B	12	B	22	A	32	A	42	C
3	C	13	A	23	B	33	C	43	A
4	B	14	B	24	A	34	B	44	C
5	B	15	A	25	D	35	B	45	B
6	A	16	A	26	B	36	B	46	B
7	C	17	B	27	B	37	D	47	B
8	B	18	A	28	C	38	D	48	A
9	A	19	B	29	A	39	D	49	D
10	B	20	D	30	D	40	B	50	A

