Electromagnetic Waves

Class 12 Physics · 24 NEET MCQs with answers & explanations

Electromagnetic Waves covers the EM spectrum, properties of EM waves, displacement current and Maxwell's equations. NEET tests the EM spectrum order (frequency, wavelength, uses), properties of EM waves and displacement current concept — mostly conceptual and factual.

EM Spectrum

Wave	Key Fact
Radio waves	Longest λ; broadcasting, communication
Microwaves	Radar, microwave ovens, satellite communication
Infrared	Heat radiation; night vision; greenhouse effect
Visible light	VIBGYOR; only EM wave detected by human eye
Ultraviolet	Vitamin D synthesis; sterilisation; causes skin cancer
X-rays & Gamma	X-rays: medical imaging; Gamma: nuclear reactions, shortest λ, highest energy

Questions

Q1. A plane electromagnetic wave travels in free space with electric-field amplitude 48 V m^{-1}. Taking c = 3 × 10^{8} m s^{-1}, what is the magnetic-field amplitude?

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

Q2. A plane electromagnetic wave in vacuum has electric-field amplitude 36 V m^{-1}. Taking c = 3 × 10^{8} m s^{-1}, its magnetic-field amplitude is:

(A) 1.2 × 10^{-7} T
(B) 1.2 × 10^{-6} T
(C) 1.08 × 10^{10} T
(D) 3.6 × 10^{-8} T

Q3. The condition under which a microwave oven heats up food containing water molecules most efficiently is:

(A) Microwaves are heat waves and always produce heating regardless of frequency
(B) Infrared waves, not microwaves, are responsible for heating in a microwave oven
(C) The frequency of microwaves has no relation with the natural frequency of water molecules
(D) The frequency of the microwaves must match the resonant frequency of water molecules

Q4. The wavelength range of visible light in the electromagnetic spectrum is approximately:

(A) 400 nm to 700 nm
(B) 10 nm to 400 nm
(C) 700 nm to 1 mm
(D) 1 mm to 0.1 m

Q5. A radio transmitter operates at a frequency of 1.368 MHz. Taking $c = 3 \times 10^8$ m/s, the wavelength of the emitted radiation is closest to:

(A) 21.93 m
(B) 219.3 m
(C) 2.193×10^3 m
(D) 219.3 cm

Q6. A microwave signal has a frequency of 3×10^9 Hz. Its wavelength in vacuum is:

(A) 1 cm
(B) 1 m
(C) 10 cm
(D) 10 m

Q7. The radiation emitted by the human body at ordinary temperatures predominantly lies in which region of the electromagnetic spectrum?

(A) Ultraviolet
(B) Infrared
(C) Visible
(D) X-rays

Q8. Which property of ultraviolet radiation makes it useful for sterilisation?

(A) Its high photon energy can damage or destroy the DNA of microorganisms
(B) Its very long wavelength penetrates deeply into materials
(C) Its lowest frequency among EM waves makes it safe to use
(D) Its inability to interact with matter allows deep penetration

Q9. The energy of an electromagnetic photon is of the order of 15 keV. To which region of the EM spectrum does it belong?

(A) Ultraviolet rays
(B) Gamma rays
(C) X-rays
(D) Infrared rays

Q10. Which electromagnetic radiation has the highest frequency and shortest wavelength in the EM spectrum?

(A) Gamma rays
(B) X-rays
(C) Ultraviolet rays
(D) Microwaves

Q11. Which electromagnetic waves are most commonly used for long-distance radio and television communication?

(A) Radio waves
(B) Infrared rays
(C) Ultraviolet rays
(D) Gamma rays

Q12. Which electromagnetic wave is used to study crystal structure by diffraction?

(A) Microwaves
(B) Ultraviolet rays
(C) X-rays
(D) Infrared rays

Q13. Which statement correctly describes visible light in the electromagnetic spectrum?

(A) It lies between infrared and ultraviolet radiation
(B) It has the longest wavelength among EM waves
(C) It has lower frequency than infrared radiation
(D) It is a mechanical wave

Q14. For a plane electromagnetic wave in vacuum, the ratio of magnetic-field amplitude B_0 to electric-field amplitude E_0 is:

(A) 1/c
(B) c
(C) c^2
(D) $\sqrt{(\mu_0/\varepsilon_0)}$

Q15. An electromagnetic wave is produced. Which of the following is the CORRECT condition for its generation?

(A) A charge moving with constant velocity
(B) An accelerating charge
(C) A stationary charge in a conductor
(D) A charge oscillating in a closed loop with zero net acceleration

Q16. An electromagnetic wave has electric-field amplitude E_0. If the amplitude becomes $2E_0$ with frequency unchanged, the new magnetic-field amplitude in vacuum is:

(A) $B_0/4$
(B) $B_0/2$
(C) B_0
(D) $2B_0$

Q17. Which of the following correctly describes a plane electromagnetic wave propagating in vacuum?

(A) E and B fields are parallel to each other
(B) E and B are in phase and perpendicular to each other and to direction of propagation
(C) E and B are out of phase by 90 degrees
(D) E and B are parallel to the direction of propagation

Q18. Consider four statements about a plane electromagnetic wave in vacuum: I. E is perpendicular to B. II. E and B are perpendicular to the direction of propagation. III. E and B are in phase. IV. E and B have different frequencies. How many statements are CORRECT?

(A) Only 1
(B) Only 2
(C) Only 3
(D) All 4

Q19. Which of the following statements about a plane electromagnetic wave propagating through vacuum is INCORRECT?

(A) E and B are mutually perpendicular
(B) E and B are perpendicular to the direction of propagation
(C) E and B oscillate in phase
(D) E and B can have different amplitudes measured in the same SI units

Q20. For a plane electromagnetic wave propagating along +z-axis in vacuum, which representation is CORRECT?

(A) $E = E_0\,\hat{i}$, $B = B_0\,\hat{j}$
(B) $E = E_0\,\hat{k}$, $B = B_0\,\hat{i}$
(C) $E = E_0\,\hat{j}$, $B = B_0\,\hat{k}$
(D) $E = E_0\,\hat{j}$, $B = B_0\,\hat{i}$ — propagation along +y

Q21. In a plane electromagnetic wave in vacuum, the ratio of average electric energy density to average magnetic energy density is:

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

Q22. Which of the following CANNOT produce a propagating electromagnetic wave?

(A) An oscillating electric dipole
(B) A charge undergoing simple harmonic motion
(C) An antenna carrying alternating current
(D) A proton moving in a straight line at constant speed

Q23. A plane electromagnetic wave in vacuum has electric-field amplitude 6×10^{-2} V/m. The amplitude of the associated magnetic field is:

(A) 2×10^{-10} T
(B) 2×10^{-8} T
(C) 2×10^{-11} T
(D) 6×10^{-2} T

Q24. In a plane electromagnetic wave, the electric and magnetic fields reach their maximum values simultaneously at a given point because:

(A) E leads B by 90 degrees in phase
(B) E and B oscillate in phase in a plane electromagnetic wave
(C) B reaches maximum first due to Lenz's law
(D) E and B have different wavelengths that coincide at that point

Answer key

1-B	**2-A**	**3-D**	**4-A**	**5-B**	**6-C**	**7-B**	**8-A**
9-C	**10-A**	**11-A**	**12-C**	**13-A**	**14-A**	**15-B**	**16-D**
17-B	**18-C**	**19-D**	**20-A**	**21-C**	**22-D**	**23-A**	**24-B**

Answers with explanations

Q1 — Answer: (B) 1.6×10^{-7} T
$B_0 = E_0/c = 48/(3 \times 10^8) = 1.6 \times 10^{-7}$ T. Option A traps students who slip one power of ten. Option C arises from using 3×10^7 in the denominator by error.

Q2 — Answer: (A) 1.2×10^{-7} T
$B_0 = E_0/c = 36/(3 \times 10^8) = 1.2 \times 10^{-7}$ T. Option B is a one-decade slip (×10 error). Option C comes from computing $E_0 \times c$ instead of E_0/c. Option D uses $c = 10^9$ m/s by mistake.

Q3 — Answer: (D) The frequency of the microwaves must match the resonant frequency of water molecules
Resonance occurs when driving frequency equals natural frequency of the system. Microwave ovens operate near 2.45 GHz matching rotational resonance of water molecules. Options A and C incorrectly deny the frequency-dependence of heating efficiency.

Q4 — Answer: (A) 400 nm to 700 nm
Visible light occupies 400–700 nm. Below 400 nm is UV; above 700 nm is infrared. Option B is the UV range; option C is infrared. This is a direct NCERT fact.

Q5 — Answer: (B) 219.3 m
$\lambda = c/f = (3\times10^8)/(1.368\times10^6) \approx 219.3$ m, placing this in the AM radio band. The trap is mishandling the MHz conversion and obtaining 21.93 m or 2193 m instead.

Q6 — Answer: (C) 10 cm
$\lambda = c/f = (3\times10^8)/(3\times10^9) = 10^{-1}$ m = 10 cm. The trap is misreading 10^{-1} m as 10^{-2} m and choosing 1 cm instead.

Q7 — Answer: (B) Infrared
Thermal radiation from a body at ordinary temperature peaks in the infrared region. This is why infrared cameras can detect humans in darkness. UV and X-rays require much higher source temperatures.

Q8 — Answer: (A) Its high photon energy can damage or destroy the DNA of microorganisms
UV photons have higher frequency and energy than visible photons ($E = hf$). This energy is sufficient to break DNA bonds in microorganisms, making UV effective for germicidal applications. Options B and C state properties that are factually opposite to UV characteristics.

Q9 — Answer: (C) X-rays
X-rays span roughly 100 eV to 100 keV in photon energy. UV photons carry only a few eV and gamma-ray photons exceed 100 keV. A 15 keV photon falls squarely in the X-ray range.

Q10 — Answer: (A) Gamma rays
Gamma rays occupy the extreme high-frequency, short-wavelength end of the EM spectrum. From $c = f\lambda$ in vacuum, highest frequency corresponds to shortest wavelength. X-rays are the closest but still lower in frequency than gamma rays.

Q11 — Answer: (A) Radio waves
Radio waves are used for broadcasting and long-distance communication due to their suitable atmospheric propagation and ability to carry modulated signals over large distances. All other options either lack propagation range or are unsuitable for communication modulation.

Q12 — Answer: (C) X-rays
X-rays have wavelengths (~0.1 nm) comparable to interatomic spacing in crystals, making them ideal for diffraction studies. UV and microwaves are too large; IR is also too large for atomic-scale diffraction.

Q13 — Answer: (A) It lies between infrared and ultraviolet radiation
Visible light lies between IR and UV in the EM spectrum. Its wavelength is shorter than IR and longer than UV. It is electromagnetic and travels through vacuum.

Q14 — Answer: (A) 1/c
Since $E_0/B_0 = c$, we get $B_0/E_0 = 1/c$. Option B (c) is the inverse ratio E_0/B_0. Option D is the intrinsic impedance of vacuum, not the E-B ratio.

Q15 — Answer: (B) An accelerating charge
Electromagnetic waves are produced by accelerating charges that create time-varying electric and magnetic fields. Constant-velocity charges do not radiate. Option D is a trap: net zero acceleration means no radiation.

Q16 — Answer: (D) $2B_0$
Since $E_0/B_0 = c$ (constant in vacuum), B_0 is directly proportional to E_0. Doubling E_0 doubles B_0. Students choosing B_0 (option C) incorrectly believe B_0 is set only by frequency.

Q17 — Answer: (B) E and B are in phase and perpendicular to each other and to direction of propagation
In a plane EM wave: E ⊥ B, both ⊥ propagation direction, and E and B oscillate in phase. Option C is a common confusion with mechanical waves where displacement and velocity can be out of phase.

Q18 — Answer: (C) Only 3
Statements I, II and III are correct. E ⊥ B, both are transverse to propagation, and they oscillate in phase. Statement IV is false — E and B have the same frequency in an electromagnetic wave.

Q19 — Answer: (D) E and B can have different amplitudes measured in the same SI units
E and B always differ in SI unit amplitude (V/m vs T) and satisfy $E_0/B_0 = c$. They cannot have equal numerical values in SI. Statements A, B and C are all correct properties of EM waves.

Q20 — Answer: (A) $E = E_0\,\hat{i}$, $B = B_0\,\hat{j}$
In option A, $\hat{i} \times \hat{j} = \hat{k}$ (propagation along +z). Option B is wrong as $\hat{k}$ is along z, not transverse. Option D gives propagation along $\hat{j} \times \hat{i} = -\hat{k}$ (−z direction). Students often forget to verify E × B = propagation direction.

Q21 — Answer: (C) 1:1
Average electric energy density $uE = \varepsilon_0 E^2/2$ and magnetic $uB = B^2/2\mu_0$. Since $E = cB$ and $c^2 = 1/\mu_0\varepsilon_0$, these are equal. Option D (c:1) arises from confusing energy density ratio with E/B ratio.

Q22 — Answer: (D) A proton moving in a straight line at constant speed
Constant velocity means zero acceleration — no radiation. Options A, B and C all involve acceleration or time-varying currents that produce EM waves. Students often choose A thinking only large structures radiate.

Q23 — Answer: (A) 2×10^{-10} T
$B_0 = E_0/c = (6 \times 10^{-2})/(3 \times 10^{8}) = 2 \times 10^{-10}$ T. Option B results from dividing only the coefficient and ignoring the 10^{-2} factor. Option D is the trap of equating $B_0 = E_0$ numerically.

Q24 — Answer: (B) E and B oscillate in phase in a plane electromagnetic wave
E and B are in phase in a plane EM wave — they reach maxima and minima together. Option A confuses EM waves with AC circuits where V and I can be out of phase. Option C misapplies Lenz's law.

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