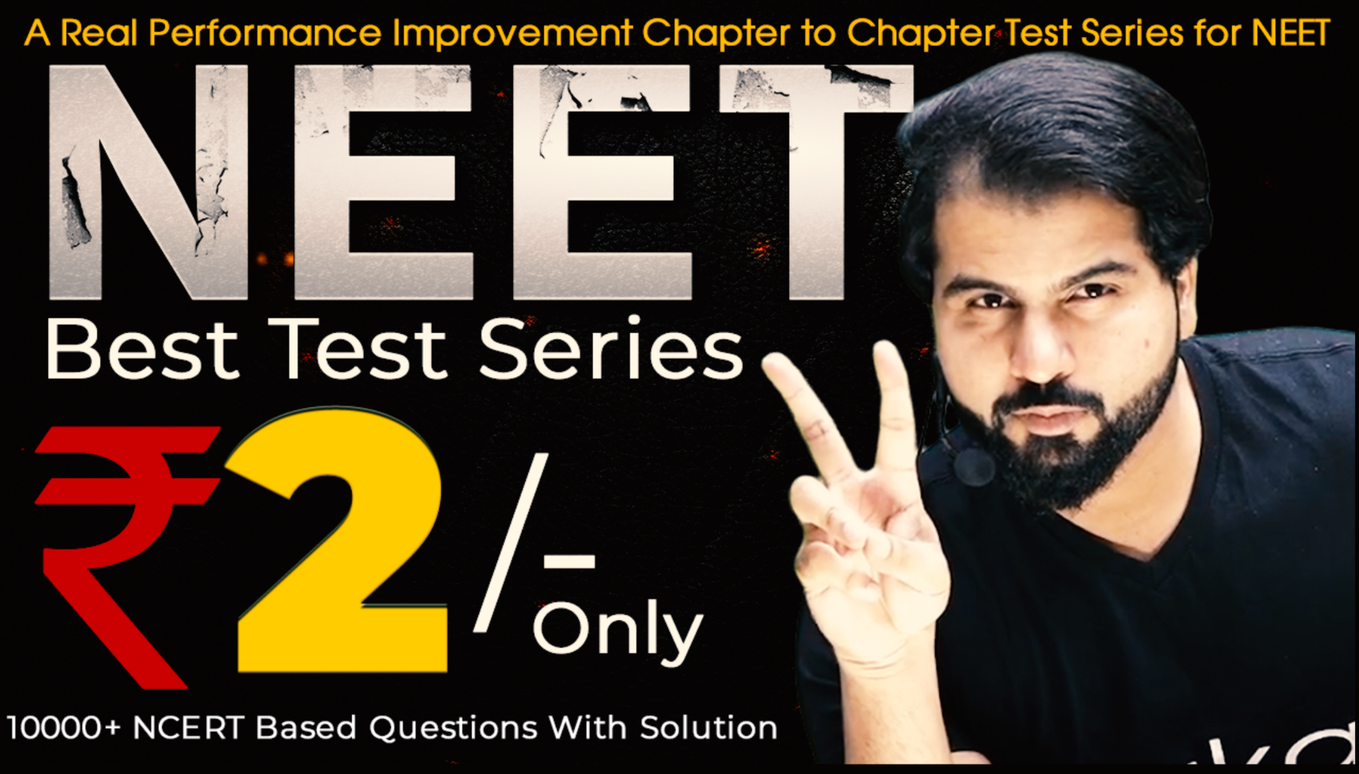
NEET CTC

Chapter to Chapter Test Series for NEET-2024

Test 64 - 25.12.2023

Physics

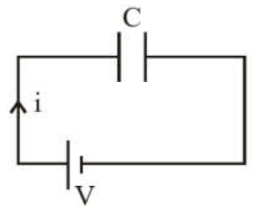
Electromagnetic Wave



PHYSICS

Electromagnetic Waves

Q.1 At a particular instant the current in the circuit given below is i. The displacement current between the plates of the capacitor shown below is



(a) Zero (b) i

(c) $\frac{i}{2}$ (d) $\frac{i}{4}$

Q.2 To establish an instantaneous displacement current of I ampere in the space between the plates of a parallel plate capacitor of $\frac{1}{2}$ farad, the value of $\frac{dV}{dt}$ is

(a) 2I (b) $\frac{I}{2}$

(c) $\frac{1}{2I}$ (d) I

Q.3 The direction of poynting vector represents

(a) The direction of electric field

(b) The direction of magnetic field

(c) The direction of propagation of EM wave

(d) The direction opposite to the propagation of EM wave

Q.4 The electric field part of an electromagnetic wave in a medium is represented by $E_x = 0$;

$$E_y = 2.5\frac{N}{C}\cos\left[\left(2\pi\times10^6\frac{rad}{s}\right)t-\left(\pi\times10^{-2}\frac{rad}{m}\right)x\right]$$

$E_z = 0$. The wave is

(a) Moving along x direction with frequency $\pi \times 10^6$ Hz and wavelength 200 m

(b) Moving along y direction with frequency $2\pi\times10^6$ Hz and wavelength 200 m

(c) Moving along x direction with frequency 10^{-6} Hz and wavelength 100 m

(d) Moving along x direction with frequency 10^6 Hz and wavelength 200 m

Q.5 In an electromagnetic wave in free space the root mean square value of the electric field is E_{rms} = 6 V/m. The peak value of the magnetic field is :

(a) 1.41×10^{-8} T

(b) 2.83×10^{-8} T

(c) 0.70×10^{-8} T

(d) 4.23×10^{-8} T

Q.6 Assertion : If the earth did not have an atmosphere, its average surface temperature would have been lower.

Reason : In the absence of atmosphere, the green house effect will be absent.

(a) Assertion and reason both are true and the reason is correct explanation of assertion.

(b) Assertion and reason both are true but reason is not correct explanation of assertion.

(c) Assertion is true but reason is wrong.

(d) Assertion and reason both are wrong.

Q.7 If ε_0 and μ_0 are the electric permittivity and magnetic permeability in a free space, ε and μ are the corresponding quantities in medium, the index of refraction of the medium is

(a) $\sqrt{\frac{\varepsilon_0\mu_0}{\varepsilon\mu}}$ (b) $\sqrt{\frac{\varepsilon\mu}{\varepsilon_0\mu_0}}$

(c) $\sqrt{\frac{\varepsilon_0\mu}{\varepsilon\mu_0}}$ (d) $\sqrt{\frac{\varepsilon}{\varepsilon_0}}$

Q.8 Assertion : When cooking in microwave ovens, metal containers are used.

Reason : Energy of the microwaves can be easily transferred to the food thorugh metal.

(a) Assertion and reason both are true and the reason is correct explanation of assertion.

(b) Assertion and reason both are true but reason is not correct explanation of assertion.

(c) Assertion is true but reason is wrong.

(d) Assertion and reason both are wrong.

Q.9 A capacitor of capacitanceC, is connected across an AC source of voltageV, given by

$V = V_0 \sin\omega t$

The displacement current between the plates of the capacitor, would then be given by

(a) $I_d = V_0 \omega C \cos\omega t$ (b) $I_d = \frac{V_0}{\omega C}\cos\omega t$

(c) $I_d = \frac{V_0}{\omega C}\sin\omega t$ (d) $I_d = V_0 \omega C \sin\omega t$

Q.10 For a plane electromagnetic wave propagating in x-direction, which one of the following combination gives the correct possible directions for electric field (E) and magnetic field (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.11 Which of the following physical quantities contained in a small volume oscillates at double the frequency of passing electromagnetic wave?

(a) Electric field (b) Magnetic field

(c) Magnetic energy (d) All of these

Q.12 Light with an average flux of 20 W/cm^2 falls on a non-reflecting surface at normal incidence having surface area 20cm^2. The energy received by the surface during time span of 1 min is

(a) 12×10^3 J (b) 24×10^3 J

(c) 48×10^3 J (d) 10×10^3 J

Q.13 A parallel plate capacitor of capacitance 20μF is being charged by a voltage source whose potential is changing at the rate of 3 V/s. The conduction current through the connecting wires and the displacement current through the plates of the capacitor, would be, respectively.

(a) 60 μA, 60 μA (b) 60 μA, zero

(c) zero, zero (d) zero, 60μA

Q.14 Out of the following options which one can be used to produce a propagating electromagnetic wave?

(a) A stationary charge

(b) A chargeless particle

(c) An accelerating charge

(d) A charge moving at constant velocity

Q.15 The ratio of amplitude of magnetic field to the amplitude of electric field for an electromagnetic wave propagating in vacuum is equal to

(a) The speed of light in vacuum

(b) Reciprocal of speed of light in vacuum

(c) The ratio of magnetic permeability to the electric susceptibility of vacuum

(d) Unity

Q.16 The electric field associated with an electro magnetic wave in vacuum is given by $E = \hat{i}\,40\cos(kz - 6\times10^8 t)$, where E, z and t are in volt/m, metre and second respectively. The value of wave factor k is

(a) 2 m^{-1} (b) 0.5 m^{-1}

(c) 6 m^{-1} (d) 3 m^{-1}

Q.17 Which of the following statement is false for the properties of electromagnetic waves?

(a) Both electric and magnetic field vectors attain the maxima and minima at the same place and same time

(b) The energy in electromagnetic wave is divided equally between electric and magnetic vectors

(c) Both electric and magnetic field vectors are parallel to each other and perpendicular to the direction of propagation of wave

(d) These waves do not require any material medium for propagation

Q.18 The wavelength of light of frequency 100 Hz is

(a) 2×10^6 m (b) 3×10^6 m

(c) 4×10^6 m (d) 5×10^6 m

Q.19 The electric and the magnetic field, associated with an e.m. wave, propagating along the +z-axis, can be represented by

(a) $[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{k}]$ (b) $[\vec{E} = E_0\hat{i}, \vec{B} = B_0\hat{j}]$

(c) $[\vec{E} = E_0\hat{k}, \vec{B} = B_0\hat{i}]$ (d) $[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{i}]$

Q.20 The energy of the EM waves is of the order of 15 keV. To which part of the spectrum does it belong?

(a) X-rays (b) Infrared rays

(c) Ultravioiet rays (d) Gamma rays

Q.21 The structure of solids is investigated by using

(a) cosmic rays

(b) X-rays

(c) γ-rays

(d) infrared radiations

Q.22 Total energy density of electromagnetic waves in vacuum is given by the relation

(a) $\frac{1}{2}\cdot\frac{E^2}{\varepsilon_0}+\frac{B^2}{2\mu_0}$ (b) $\frac{1}{2}\varepsilon_0 E^2+\frac{1}{2}\mu_0 B^2$

(c) $\frac{E^2+B^2}{c}$ (d) $\frac{1}{2}\varepsilon_0 E^2+\frac{B^2}{2\mu_0}$

Q.23 Assertion : Infrared waves are often called heat waves.

Reason : Infrared waves vibrate not only the electrons, but entire atoms or molecules of a substance which increases the internal energy and temperature of the substance.

(a) Assertion and reason both are true and the reason is correct explanation of assertion.

(b) Assertion and reason both are true but reason is not correct explanation of assertion.

(c) Assertion is true but reason is wrong.

(d) Assertion and reason both are wrong.

Q.24 An EM wave radiates outwards from a dipole antenna, with E_0 as the amplitude of its electric field vector. The electric field E_0 which transports significant energy from the source falls off as

(a) $\frac{1}{r^3}$ (b) $\frac{1}{r^2}$

(c) $\frac{1}{r}$ (d) remains constant

Q.25 The electric field associated with an electromagnetic wave in vacuum is given by $E = 40\cos(kz - 6\times 10^8 t)$, where E, Z and t are in volt/m, meter and second respectively. The value of the wave number would be :

(a) 2 m^{-1}

(b) 0.5 m^{-1}

(c) 6 m^{-1}

(d) 3 m^{-1}

Q.26 According to modified Ampere's circuital law (i_D = displacement current)

(a) $\oint \vec{B}\cdot\vec{dl}=\mu_0\left(i_C+\varepsilon_0\frac{d\phi_E}{dt}\right)$

(b) $\oint \vec{B}\cdot\vec{dl}=\mu_0\,\varepsilon_0\frac{d\phi_E}{dt}$

(c) $\oint \vec{B}\cdot\vec{dl}=\mu_0\, i$

(d) $\oint \vec{B}\cdot\vec{dl}=\mu_0\left(i_C\frac{d\phi_E}{dt}+i_D\right)$

Q.27 Displacement current is set up between the plates of a capacitor when the potential difference across the plates is

(a) Maximum (b) Zero

(c) Minimum (d) Varying

Q.28 The following can be arranged in decreasing order of wave number

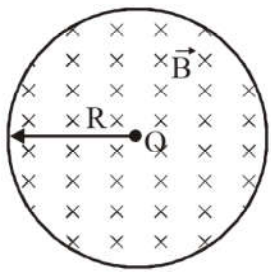
A. AM radio **B. TV and FM radio**

C. Microwave **D. Short radio wave**

(a) A > B > D > C (b) C > D > B > A

(c) A > B > C > D (d) D > C > B > A

Q.29 Figure shows a circular region of radius R in which uniform magnetic field B exists. The magnetic field is increasing at a rate $\frac{dB}{dt}$. The induced electric field at a distance r from the centre for r < R is



(a) $\frac{dB}{dt}\frac{r}{2}$ (b) Zero

(c) $\frac{dB}{dt}$ (d) $\frac{dB}{dt}\frac{R^2}{2r}$

Q.30 In a plane electromagnetic wave, which of the following has/ have zero average value in one complete cycle?

(i) Magnetic field **(ii) Magnetic energy**

(iii) Electric field **(iv) Electric energy**

(a) (i), (iii) (b) (ii), (iii)

(c) (i), (iv) (d) All

Q.31 If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic field vectors of an electromagnetic wave, then the direction of propagation of the electromagnetic wave is in the direction of

(a) $\vec{E}$ (b) $\vec{B}$

(c) $\vec{E}\times\vec{B}$ (d) $\vec{B}\times\vec{E}$

Q.32 An electromagnetic wave is propagating in vacuum along z-axis, the electric field component is given by $E_x = E_0 \sin(kz - \omega t)$, then magnetic component is

(a) $B_x = \frac{E_0}{C}\sin(kz-\omega t)$

(b) $B_y = \frac{B_0}{C}\sin(kz-\omega t)$

(c) $B_y = \frac{E_0}{C}\sin(kz-\omega t)$

(d) $B_y = B_0 C\sin(kz-\omega t)$

Q.33 Electromagnetic wave is deflected by

(a) Electric field

(b) Magnetic field

(c) Both (a) & (b)

(d) Neither electric field nor magnetic field

Q.34 Out of the following, choose the ray which does not travel with the velocity of light

(a) X-ray (b) Microwave

(c) γ-rays (d) β-rays

Q.35 Red light differs from blue light in its

(a) Speed (b) Frequency

(c) Intensity (d) Amplitude

Q.36 Which of the following has the largest wavelength?

(a) Radio wave (b) X-ray

(c) Ultraviolet ray (d) Infra-red ray

Q.37 Velocity of electromagnetic waves in a medium is

(a) $(\varepsilon_0\mu_0)^{-1/2}$ (b) $(\varepsilon_0\varepsilon_r\mu_0\mu_r)^{-1/2}$

(c) 3×10^8 m/s (d) $\left(\frac{\varepsilon_0\varepsilon_r}{\mu_0\mu_r}\right)^{+1/2}$

Q.38 Which of the following is incorrect about a plane electromagnetic wave?

(a) The electric field and magnetic field have equal average values

(b) The electric energy and the magnetic energy have equal average values

(c) The electric field and magnetic field both oscillate in same phase

(d) The electric field and magnetic field oscillate in opposite phase

Q.39 The speed of electromagnetic wave in a medium whose dielectric constant is 2.25 and relative permeability is 4 is equal to

(a) 0.5×10^8 m/s (b) 0.25×10^8 m/s

(c) 0.75×10^8 m/s (d) 1×10^8 m/s

Q.40 The magnetic field in a plane electromagnetic wave is given by = $2 \times 10^{-7}\sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$. This electromagnetic wave is

(a) Visible light (b) Infrared

(c) Microwave (d) Radiowave

Q.41 The dimensional formula of $\frac{1}{2}\varepsilon_0 E^2$ is

(a) $[M L T^{-1}]$ (b) $[M L^2 T^{-2}]$

(c) $[M L^{-1} T^{-2}]$ (d) $[M L^2 T^{-1}]$

Q.42 Which of the following is not transported by electromagnetic waves?

(a) Energy (b) Momentum

(c) Charge (d) Information

Q.43 Which of the following represents an infra-red wavelength?

(a) 10^{-4} cm (b) 10^{-5} cm

(c) 10^{-6} cm (d) 10^{-7} cm

Q.44 The speed of electromagnetic wave in vacuum

(a) increases as we move from γ-rays to radio waves

(b) decreases as we move from γ-rays to radio waves

(c) is same for all of them

(d) None of the above

Q.45 Ozone layer blocks the radiation of wavelength

(a) Less than 3×10^{-7} m

(b) Between 3×10^{-7} m to 8×10^{-7} m

(c) More than 8×10^{-7} m

(d) None of these

Q.46 **If λ_v, λ_x and λ_m represent the wavelengths of visible light. X-rays and microwaves respectively, then**

(a) $\lambda_m > \lambda_x > \lambda_y$ (b) $\lambda_m > \lambda_v > \lambda_x$

(c) $\lambda_v > \lambda_x > \lambda_m$ (d) $\lambda_v > \lambda_m > \lambda_x$

Q.47 **If the electric field and magnetic field of an electromagnetic wave are related as $B = \frac{E}{c}$ where the symbols have their usual meanings and the energy in a given volume of space due to the electric field part is U, then the energy due to the magnetic field part will be**

(a) $\frac{U}{c}$ (b) $\frac{U}{c^2}$

(c) $\frac{U}{2}$ (d) U

Q.48 **5% of the power of 100 W bulb is converted to visible radiation. Average intensity of visible radiation at a distance of 10 m from the bulb is**

(a) $\frac{5}{2\pi(10)^2}$ watt / m^2 (b) $\frac{5}{4\pi(10)^2}$ watt / m^2

(c) $\frac{5}{\pi(10)^2}$ watt / m^2 (d) $\frac{5}{8\pi(10)^2}$ watt / m^2

Q.49 **A capacitor is connected across a battery which delivers a current of 1 A at an instant in the capacitor. Displacement current through the capacitor at that instant is**

(a) 1 A (b) 0 A

(c) 2 A (d) $\frac{1}{2}$A

Q.50 **A plane electromagnetic wave is incident on a plane surface of area A normally, and is perfectly reflected. If energy E strikes the surface in time t then average pressure exerted on the surface is (c = speed of light)**

(a) Zero (b) $\frac{E}{Atc}$

(c) $\frac{2E}{Atc}$ (d) $\frac{E}{c}$

Solution

1. (b)

Displacement current $i_d = i$

2. (a)

$$I_d = \frac{A\varepsilon_0}{d}\frac{dE}{dt} \times d$$

$$I = \frac{1}{2}\frac{dE}{dt} \times d$$

$$I = \frac{1}{2}\frac{dV}{dt} \times \frac{1}{d}.d$$

$$\frac{dV}{dt} = 2I$$

3. (c)

$$\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$$

$\vec{E} \times \vec{B} \Rightarrow$ direction of wave propagation

4. (d)

$$E_x = 0$$

$$E_y = 2.5\frac{N}{C} \text{ as } (2\pi \times 10^6 t - \pi \times 10^{-2} x)$$

$$E_z = 0$$

$$f = \frac{\omega}{2\pi} = \frac{2\pi \times 10^6}{2\pi} = 10^6 s^{-1}$$

$$\lambda = \frac{2\pi}{K} = \frac{2\pi}{\pi \times 10^{-2}} = 200\,m.$$

5. (b)

$$E_{rms} = 6\,V/m$$

$$E_0 = E_{rms} \times \sqrt{2} = 6\sqrt{2}\,V/m$$

$$B_0 = \frac{E_0}{C} = \frac{6\sqrt{2}}{3 \times 10^8}$$

$$B_0 = 2.83 \times 10^{-8}\,T$$

6. (a)

If the earth didnot have atmosphere, the average surface temperature of earth will be lower because there will be no green house effect in the absence of atmosphere.

7. (b)

$$\text{Refractive index } = \frac{C}{V}$$

$$\therefore \quad V = \frac{1}{\sqrt{\mu\varepsilon}}$$

$$C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$$\therefore \quad \eta = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$$

8. (d)

The atoms of metallic container are set into forced vibration by the micro waves. Hence, energy of microwave is not sufficient transferred to the metallic container & metallic container cannot be used.

9. (a)

Given, AC source voltage,

$V = V_0 \sin\omega t$ ...(i)

We know that,

$Q = CV$ ...(ii)

Here, Q is the charge on the capacitor,

C is the capacitance of the capacitor,

V is the AC source voltage.

On differentiate Eq. (ii) w.r.t. time, we get

$$\frac{dQ}{dt} = \frac{d(CV)}{dt}$$

$$\Rightarrow \frac{dQ}{dt} = \frac{Cd(V_0 \sin\omega t)}{dt} \quad \text{[from Eq. (i)]}$$

$$\Rightarrow \frac{dQ}{dt} = C\omega V_0 \cos\omega t$$

As we know, the displacement current,

$$I_d = \frac{dQ}{dt}$$

$$\Rightarrow I_d = V_0\omega C \cos\omega t$$

10. (b)

We know that, in electromagnetic wave, the electric field (E) and magnetic field (B) are perpendicular to each other,

$$E \cdot B = 0$$

Consider the option (a);

$$(\hat{j}+\hat{k})\cdot(\hat{j}+\hat{k})=1+1=2\neq 0$$

So, it is incorrect option.

Consider the option (b);

$$(-\hat{j}+\hat{k})\cdot(-\hat{j}-\hat{k})=1-1=0$$

Hence, it satisfies the condition $E\cdot B=0$

Similarly, options (c) and (d) are incorrect.

So, the correct option is (b).

11. (c)

The electric and magnetic energy oscillate at double the frequency as compared to electric and magnetic field.

12. (b)

Given, average flux = 20 W/cm^2

Surface area = 20 cm^2

Time = 1min = 60 s

For non-reflecting surface,

energy received = average flux × surface area × time

$= 20 \times 20 \times 60 = 24 \times 10^3$ J

13. (a)

The displacement current is precisely equals to the conduction current, when the two are present in different parts of the circuit.

Given, $C = 20\mu F = 20 \times 10^{-6}$ F and

$$\frac{dV}{dt}=3\,V/s$$

The displacement current in a circuit is given by

$$I_d=\varepsilon_0\frac{d\phi}{dt} \qquad \text{[from Maxwell's equation]}$$

$$=\varepsilon_0\frac{d}{dt}(EA) \qquad [\because \phi = EA]$$

$$=\varepsilon_0 A\frac{d}{dt}\left(\frac{V}{d}\right) \qquad [\because V = Ed]$$

$$=\frac{\varepsilon_0 A}{d}\frac{dV}{dt}$$

As the capacitance, $C=\dfrac{\varepsilon_0 A}{d}$

$$\therefore \quad I_d = C\frac{dV}{dt}$$

Substituting the given values, we get

$$I_d = 20\times 10^{-8}\times 3$$

$$=60\times 10^{-6}A = 60\mu A$$

As displacement current is in between the plates of capacitor and conduction current is in the connecting wires which are equal to each other. So,

$$I_c = I_d = 60\mu A$$

14. (c)

A particle is known that an electric charge at rest has electric field in the region around it, but no magnetic field. A moving charge produces both the electric and magnetic fields. If a charge is moving with a constant velocity, the electric and magnetic fields will not change with time, hence no EM wave will be produced. But if the charge is moving with a non-zero acceleration, both the electric and magnetic field will change with space and time, it then produces EM wave. This shows that accelerated charge emits electromagnetic waves.

15. (b)

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

$$\therefore \quad \frac{B_0}{E_0}=\frac{1}{C}$$

16. (a)

Electromagnetic wave equation is given by

$$E = E_0\cos(kz-\omega t) \qquad \ldots(i)$$

Speed of electromagnetic wave, $v=\dfrac{\omega}{k}$

Given, equation is

$$E=\hat{i}40\cos(kz-6\times 10^8 t) \qquad \ldots(ii)$$

Comparing Eqs. (i) and (ii), we get

$$\omega = 6\times 10^8 \text{ and } E_0 = 40\hat{i}$$

Here, wave factor,

$$k=\frac{\omega}{v}=\frac{6\times 10^8}{3\times 10^8}=2\,m^{-1}$$

17. (c)

The time varying electric and magnetic fields are mutually perpendicular to each other and also perpendicular to the direction of propagation.

18. (b)

The relation between velocity of light (c), frequency (v) and wavelength (λ) is

$$c = v\lambda$$

Thus, wavelength $\lambda = \frac{c}{v}$

Given, $c = 3\times10^8\ \text{m/s},\ v = 100\,\text{Hz}$

$$\therefore\ \lambda = \frac{3\times10^8}{100} = 3\times10^6\,\text{m}$$

19. (b)

If wave is propagating in +z direction then $\vec{E}$ and $\vec{B}$ will be in x-y plane.

Also, $\vec{E}\times\vec{B}$ = direction of propagation

$$\vec{E} = E_0\hat{i},\ \vec{B} = B_0\hat{j}$$

20. (a)

Given, energy of EM waves is of the order of 15 keV

i.e. $E = hv = h\times\frac{c}{\lambda}$

$$\Rightarrow \lambda = \frac{h\times c}{E} = \frac{6.624\times10^{-34}\times3\times10^{18}}{15\times10^3\times1.6\times10^{-19}}$$

$$= \frac{1.3248\times10^{-29}}{1.6\times10^{-19}} = 0.828\times10^{-10}\,\text{m}$$

$$= 0.828\,\text{Å} \qquad [\because 1\text{Å} = 10^{-10}\,\text{m}]$$

$$\lambda = 0.828\text{Å}$$

Thus, this spectrum is a part of X-rays.

21. (b)

Due to high penetrating power of X-rays, X-rays are used for investigation of structure of solids.

Lane spot method and rotating cylinder method are used for this purpose.

X-rays fall on solid under investigation and their structure is received on photographic plate.

22. (d)

The energy in EM waves is divided equally between the electric and magnetic fields.

The total energy per unit volume, $u = u_e + u_m$

$$= \frac{1}{2}\varepsilon_0E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$$

23. (a)

Infrared waves whenever encounter any object, they cause entire atoms and molecules to vibrate. Due to these vibrations, the internal energy and temperature of the object increases. Due to this infrared waves are called heat waves.

24. (c)

From a dipole antenna, the electromagnetic waves are radiated outwards.

The amplitude of electric field vector E_0 which transports significant energy from the source falls off inversely as the distance r from the antenna,

i.e. $E_0 \propto \frac{1}{r}$.

25. (a)

$$E = E_0\cos(kz - \omega t)$$

we get, $\omega = 6\times10^8\,\text{s}^{-1}$

$$K = \frac{\omega}{c} = \frac{6\times10^8}{3\times10^8} = 2\text{m}^{-1}$$

26. (a)

According to modified Ampere's circuital law.

$$\oint\vec{B}\cdot\vec{dl} = \mu_0\left(i_C + \varepsilon_0\frac{d\phi_E}{dt}\right)$$

27. (d)

Displacement current, $I_d = A\varepsilon_0\frac{dE}{dt}$

So, the potential difference has to change with time

28. (b)

Decreasing order of wave number

Microwave > short radiowave > TV and FM radio > AM radio.

29. (a)

Rate of increase of $B = \frac{dB}{dt}$

$E_{in} \times 2\pi r = -\frac{d\phi}{dt}$

or $E \times 2\pi r = -A\frac{dB}{dt}$

$E \times 2\pi r = -\pi r^2 \frac{dB}{dt}$

$\therefore E = \frac{-r}{2}\frac{dB}{dt}$

30. (d)

Both $\vec{E}$ and $\vec{B}$ are sinusoidal, so over a complete cycle, its value will be zero.

31. (c)

Direction of propagation is given by $\vec{E} \times \vec{B}$

32. (c)

Direction of propagation $\to Z$

$E_x = E_0 \sin(kZ - \omega t)$

$\vec{B} \to$ will be in the y-direction

$\therefore B_y = B_0 \sin(kZ - \omega t)$

$\therefore \frac{E_0}{B_0} = C$

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

So, $B_y = \frac{E_0}{c}\sin(kZ - \omega t)$

33. (d)

Electromagnetic wave consists of uncharged particle called photons which are neither deflected by electric field nor by magnetic field.

34. (d)

$\beta -$ rays do not travel with speed of light, as they are not *em* waves.

35. (b)

Frequency is different for each light as they have different wavelengths.

36. (a)

Radio waves : 10^{-2} m to 10^4 m.

37. (b)

Speed of light in medium $= \frac{1}{\sqrt{\mu\varepsilon}} = \frac{1}{\sqrt{\mu_0\mu_r\varepsilon_0\varepsilon_r}}$

$= (\mu_0\mu_r\varepsilon_0\varepsilon_r)^{-\frac{1}{2}}$

38. (d)

$\vec{E}$ and $\vec{B}$ are in the same phase but oscillate in different planes which are perpendicular to each other.

39. (d)

$E_r = 2.25,\ \mu_r = 4$

$V = \frac{1}{\sqrt{\mu_0\mu_r\varepsilon_0\varepsilon_r}}$

$= \frac{1}{\sqrt{\mu_0\varepsilon_0}} \times \frac{1}{\sqrt{2.25 \times 4}}$

$= \frac{3 \times 10^8}{1.5 \times 2}$

$V = 10^8\, m/s$

40. (c)

$B = 2 \times 10^{-7}\sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$

$f = \frac{v}{\lambda},\quad k = 0.5 \times 10^3$

$\omega = 1.5 \times 10^{11}$

$V = \frac{\omega}{k} = \frac{1.5 \times 10^{11}}{0.5 \times 10^3} = 3 \times 10^8$

$\frac{\omega}{k} = f\lambda$

$k = \frac{2\pi}{\lambda}$

$\therefore \lambda = \frac{2\pi}{k} = \frac{2 \times 22}{7 \times 0.5 \times 10^3} = 1.25 \times 10^{-2}\, m$

Microwave

41. (c)

$\frac{1}{2}\varepsilon_0 E^2 = \text{Energy density} = \frac{E}{V} = \frac{[ML^2T^{-2}]}{[L^3]}$

$= [ML^{-1}T^{-2}]$

42. (c)

Only energy, momentum and information can be transferred with the help of em waves, not any matter (like charge).

43. (a)

10^{-6} m or 10^{-4} cm $\Rightarrow$ Infrared

44. (c)

Speed of electromagnetic waves in vacuum

$$= \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = v\lambda$$

= constant

As, we go from γ-rays to radio waves frequency decreases and wavelength increases thereby maintaining the product constant.

45. (a)

Radiation having wavelength less than 3×10^{-7} m are blocked by ozone layer

46. (b)

S.No.	Type of Radiation	Wave length
1	X-Rays	$\sim 10^{-8}$ m to 10^{-12} m
2	Visible Light	$\sim 10^{-7}$ m
3	Micro waves	10^{-1} m to 10^{-3} m

$\Rightarrow \lambda_m > \lambda_v > \lambda_x$

47. (d)

$$B = \frac{E}{C}$$

Enery due to $E = \frac{1}{2}\varepsilon_0 E^2$

Energy due to $B = \frac{B_0^2}{2\mu_0}$

$E_{part} = U \qquad B_{part} = U$

$E_{part} = B_{part} = U$

48. (b)

$$I = \frac{E}{At} = \frac{P}{A}$$

$$= \frac{P}{4\pi r^2} = \frac{\frac{5}{100} \times 100}{4\pi(10)^2} = \frac{5}{400\pi} \text{watt}/\text{m}^2$$

49. (a)

I = 1 A

$I_d = 1$ A

The magnitude of displacement current between the plates of a capacitor is equal to the magnitude of conducting current flowing in the wires.

50. (c)

$$P = \frac{2I}{c} \text{ [Perfect reflection]}$$

$$= \frac{2 \times E}{Atc}$$

$$\therefore \quad P = \frac{2E}{Atc}$$