(1) **(D).** Here, $\vec{B} = 1.2 \times 10^{-8} \hat{k} T$

The magnitude of $\vec{E}$ is

$E = Bc = (1.2 \times 10^{-8}\ T)(3 \times 10^8\ m/s)$
$= 3.6\ V/m$

$\vec{B}$ is along Z-direction and the wave propagates along X-direction. Therefore, $\vec{E}$ should be in a direction perpendicular to both X and Z axes. Using vector algebra $\vec{E} \times \vec{B}$ should be along X-direction.

Since $(+\hat{j}) \times (+\hat{k}) = \hat{i}$, $\vec{E}$ is along the Y-direction. Thus, $\vec{E} = 3.6\ \hat{j}\ Vm^{-1}$

(2) **(D).** $I_D = 1\ mA = 10^{-3}\ A$
$C = 2\ \mu F = 2 \times 10^{-6}\ F$

$$I_D = I_C = \frac{d}{dt}(CV) = C\frac{dV}{dt}$$

$$\frac{dV}{dt} = \frac{I_D}{C} = \frac{10^{-3}}{2 \times 10^{-6}} = 500\ Vs^{-1}$$

Therefore, applying a varying potential difference of 500 VS^{-1} would produce a displacement current of desired value.

(3) **(C).** Refractive index of medium is = c/v

where $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ and $v = \frac{1}{\sqrt{\mu_0 \varepsilon_0 \mu_r \varepsilon_r}}$

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

Given, $\mu_r = \mu_0$ and $\varepsilon_r = \varepsilon_0$ then

$\mu = \sqrt{\mu_0 \varepsilon_0}$

(4) **(D).** Electromagnetic wave consists of periodically oscillating electric and magnetic vectors in mutually perpendicular planes but vibrating in phase.

(5) **(A).** Both magnetic and electric fields have zero average value in a plane electromagnetic wave.

(6) **(B).** Crystal structure can be studied using X-rays.

(7) **(B).** Infrared radiation plays an important role in maintaining the earth's warmth through greenhouse effect. Incoming visible light when passes relatively easily through the atmosphere is absorbed by the earth's surface and radiated as infrared (longer wavelength) radiation. This radiation is trapped by greenhouse gases such as carbon dioxide and water vapour. In this way an average temperature is maintained.

(8) **(C).** In vacuum X-rays, gamma rays and microwaves travel with same velocity, i.e., with the velocity of light e (= 3×10^8 m/s) but have different wavelengths.

(9) **(C).** $E = 11\ eV = 11 \times 1.6 \times 10^{-19}\ J = h\nu$

$$\therefore \quad \nu = \frac{11 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}} = 2.6 \times 10^{15}\ Hz$$

This frequency belongs to ultraviolet region.

(10) **(B).** As the wall is perfectly reflecting, there is no change in amplitude E_0.
Also the wall is optically inactive, so, there is no phase change.
After reflection, the wave travels along -ve z direction,

$\therefore \quad \vec{E}_r = E_0 \hat{i} \cos(-kz - \omega t)$

$= E_0 \hat{i} \cos(kz + \omega t)$ $[\because (\cos(-\theta) = \cos\theta]$

(11) **(A).** Electric field intensity on a surface due the incident radiation is

$$E = \frac{U}{At} = \frac{P}{A} \quad \left(\because \frac{U}{t} = P\right)$$

$\therefore$ $E \propto P$ (for the given area of the surface)

$$\therefore \quad \frac{E'}{E} = \frac{P'}{P} = \frac{50}{100} = \frac{1}{2}\ ; \quad E' = \frac{E}{2}$$

(12) **(A).** Energy is equally divided between electric and magnetic field.

(13) **(C).** Intensity of electromagnetic wave,
$I = U_{av}\, c$

In terms of electric field, $U_{av} = \frac{1}{2}\varepsilon_0 E_0^2$

In terms of magnetic field, $U_{av} = \frac{1}{2}\frac{B_0^2}{\mu_0}$

Now U_{av} (due to electric field) $= \frac{1}{2}\varepsilon_0 E_0^2$

$$= \frac{1}{2}\varepsilon_0 (cB_0)^2 = \frac{1}{2}\varepsilon_0 \times \frac{1}{\mu_0\varepsilon_0} B_0^2$$

$(\because E_0/B_0 = c)$

$$= \frac{1}{2}\frac{B_0^2}{\mu_0} = U_{av} \text{ (due to magnetic field)}$$

Therefore, the ratio of contributions by the electric field and magnetic field components to the intensity of electromagnetic wave is 1 : 1.

(14) **(C).** From a dipole antenna, the electromagnetic waves are radiated outwards. The amplitude of electric vector E_0 which transports significant energy from the source falls off inversely as the distance r from the antenna i.e., $E_0 \propto 1/r$.

(15) **(A).** If the total energy transferred to a surface in time t is u, then the magnitude of the total momentum delivered to this surface (for complete absorption) is, P = u/c.

(16) **(A).** $I = \frac{P}{4\pi r^2} = U_{av} \times c$ .... (1)

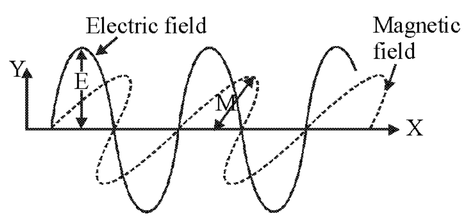
$U_{av} = \frac{1}{2}\varepsilon_0 E_0^2$ .... (2)

$$\Rightarrow \frac{P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E_0^2 \times c$$

$$\Rightarrow E_0 = \sqrt{\frac{2P}{4\pi r^2 \varepsilon_0 c}} = 2.45 \text{ V/m}$$

(17) **(C).** Electromagnetic radiation is a self propagating wave in space with electric and magnetic components.

These components oscillate at right angles to each other and to the direction of propagation.



Hence, B is along the Z-axis at that time.

(18) **(A).** Total average energy density of the electromagnetic

$= \varepsilon_0 E^2_{rms} = 8.85 \times 10^{-12} \times (720)^2$

$= 4.58 \times 10^{-6}$ Jm^{-3}

(19) **(C).** As electric field intensity

i.e., $E_0 = cB_0$ or $c = \frac{E_0}{B_0}$ ..... (1)

where, c is speed of light and B_0 is magnetic field.

Also, speed of light i.e., $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ ..(2)

where μ_0 and ε_0 are absolute permeability and permittivity in free space in vacuum.

On comparing eqs. (1) and (2), we get

$$\frac{E_0}{B_0} = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \Rightarrow \sqrt{\mu_0\varepsilon_0} \times E_0 = B_0$$

(20) **(B).** Infrared waves → To treat muscular strain

Radio waves → for broadcasting

X-rays → To detect fracture of bones

Ultraviolet rays → Absorbed by the ozone layer of the atmosphere.

(21) **(B).** We know $E = \frac{hc}{\lambda} \Rightarrow E \propto \frac{1}{\lambda}$

$$E_m < E_v < E_x \quad \therefore \lambda_m > \lambda_v > \lambda_x$$

(22) **(D).** $v = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ a standard formula

(23) **(B).** $E_y = E_0 \cos(\omega t - kx)$

$\omega = 2\pi f = 2\pi \times 10^6 \quad \therefore f = 10^6$ Hz

$k = \frac{2\pi}{\lambda} = \pi \times 10^{-2}$ m^{-1}, $\lambda = 200$m

(24) **(C).** The wavelength λ, frequency f, and speed c of an electromagnetic wave are related according to c = λf, where c is the same for any electromagnetic wave traveling in a vacuum and is independent of λ and f.

Since c is constant, λ and f are inversely proportional. When f is reduced by a factor of three, λ increases by a factor of three.

(25) **(B).** The loop can only detect the wave if the wave's magnetic field has a component perpendicular to the plane of the loop, that is, along the y axis. Only then will there be a changing magnetic flux through the loop. The changing flux is needed, so that an induced emf will arise in the loop according to Faraday's law of electromagnetic induction. The electric and magnetic fields of an electromagnetic wave are mutually perpendicular and are both perpendicular to the direction in which the wave travels. Thus, when the wave travels along the z axis with its electric field along the x axis, the magnetic field will be along the y axis as needed.

(26) **(A).** The magnitudes of the electric and magnetic fields of the wave are proportional, according to E = c B . Thus, when E doubles, so does B. The total energy density and the intensity are each proportional to the square of the electric field magnitude, according to $u = \varepsilon_0 E^2$ and $S = c\varepsilon_0 E^2$, Therefore, when E doubles, u and S both increase by a factor of $2^2 = 4$.

(27) **(C).** $I = \frac{P}{A}$ or $\frac{2}{4\pi \times 4} = \frac{1}{8\pi}$ W/m^2

$$I = \frac{1}{2} \in_0 E_0{}^2 c$$

$$E_0 = \sqrt{\frac{2I}{\in_0 C}} \text{ or } \sqrt{\frac{2 \times 1 \times 36\pi}{8\pi \times 3 \times 10^8}}$$

$$= \sqrt{3} \times 10^{-4} \text{N/C}$$

(28) **(A).** Given

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

Comparing it with a standard equation for a progresive wave travelling along the negative direction of x-axis is

$$y = r \sin \frac{2\pi}{\lambda} (x + vt) = r \sin\left(\frac{2\pi x}{\lambda} + \frac{2\pi vt}{\lambda}\right)$$

$$= r \sin\left(\frac{2\pi x}{\lambda} + 2\pi vt\right)$$

We have, $\frac{2\pi x}{\lambda} = 0.5 \times 10^3 x$

or $\lambda = \frac{2\pi}{0.5 \times 10^3} = 12.56 \times 10^{-3} x = 12.56$mm

$2\pi\nu = 1.5 \times 10^{11}$

$$\nu = \frac{1.5 \times 10^{11}}{2\pi} = 23.9 \times 10^9 \text{ Hz} = 23.9 \text{ Hz}$$

(29) **(C).** The given equation

$E_y = 0.5 \cos[2\pi \times 10^8 (t - x/c)]$ ..... (1)

indicates that the electromagnetic waves are propagating along the positive direction of X-axis.

The standard equation of electromagnetic wave is given by

$E_y = E_0 \cos\omega(t - x/c)$ ..... (2)

Comparing the given eq. (1) with the standard eq. (2), we get $\omega = 2\pi \times 10^8$

or $2\pi\nu = 2\pi \times 10^8$

$\therefore$ $\nu = 10^8$ per second

Now, $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{10^8} = 3$ m

(30) **(A).** The maximum value of magnetic field (B_0) is given by $B_0 = \frac{E_0}{c} = \frac{E_0}{c} = 10^{-6}$ tesla

The magnetic field will be along Z-axis

The maximum magnetic force on the electron is

$F_b = |q(\mathbf{v} \times \mathbf{B})| = q\, v\, B_0$

$= (1.6 \times 10^{-19}) \times (2.0 \times 10^7) \times (10^{-6})$

$= 3.2 \times 10^{-18}$ N

(31) **(B).** We know that

$$d = \sqrt{(2hR)} = \sqrt{2 \times 160 \times (6.4 \times 10^6)} = 45255 \text{ m}$$

(32) **(A).** Population covered = $\pi d^2 \times$ population density

$= 3.14 \times (45.255)^2 \times 1200$

$= 77.29$ lakh

(33) **(C).** In this case, d' = $\sqrt{(2h'R)} = 2d$

$\therefore$ $\sqrt{(2h'R)} = 2 \times \sqrt{(2h'R)}$

$h' = 4h = 4 \times 160 = 640$ m

$\therefore$ Increase in height of tower = h' – h

$= 640 - 160 = 480$ m.

(34) **(D).** Here, R = 12 cm = 0.12 m,

d = 5.0 mm = 5×10^{-3} m., I = 0.15 A,

$\in_0 = 8.85 \times 10^{-12}\, C^2N^{-1}m^{-2}$

$\therefore$ Area, $A = \pi R^2 = 3.14 \times (0.12)^2 m^2$]

We know that capacity of a parallel plate capacitor is given by

$$C = \frac{\in_0 A}{d} = \frac{8.85 \times 10^{-12} \times 3.14 \times (0.12)^2}{5 \times 10^{-3}}$$

$= 80.1 \times 10^{-12}$ F = 80.1 pF

Now, q = CV

or $\frac{dq}{dt} = C \times \frac{dV}{dt}$

or $I = C\frac{dV}{dt}$ $(\because I = \frac{dq}{dt})$

or $\frac{dV}{dt} = \frac{I}{C} = \frac{0.15}{80.1\times10^{-12}} = 1.87 \times 10^9\ Vs^{-1}$

(35) **(B).** Molecular spectra due to vibrational motion lie in the microwave region of EM-spectrum. Due to Kirchhoff's law in spectroscopy the same will be absorbed.

(36) **(D).**

$\nu_{\gamma-rays} > \nu_{visible\ radiation} > \nu_{Infrared} > \nu_{Radio\ waves}$

(37) **(A), (38) (B), (39) (D), (40) (A), (41) (C).**

Here $\vec{E} = [3.1 \cos (1.8\,y + 5.4 \times 10^6 t)]\ \hat{i}$. Comparing it with standard equation, $\vec{E} = [E_0 \cos (ky + \omega t)]\ \hat{i}$ we get the following answers

(a) Wave is propagating along $-\hat{j}$ direction i.e. negative y direction because coefficient of y is positive

(b) Using $k = \frac{2\pi}{\lambda}$, we get

$\lambda = \frac{2\pi}{k} = \frac{2\pi}{1.8} = 3.5m$

(c) Frequency, $\nu = \frac{c}{\lambda} = \frac{3\times10^8}{3.5} = 86\ MHz$

(d) $c = \frac{E_0}{B_0}$ or $B_0 = \frac{E_0}{c} = \frac{3.1}{3\times10^8} = 10nT$

(e) Using, $\vec{B} = -B_0 \cos (ky + \omega t)\ \hat{k}$

[E is along $\hat{i}$, c is along $-\hat{j}$, c is in direction of $\vec{E}\times\vec{B}$
$-\hat{j} = \hat{i}\times\hat{k}$ $\therefore$ $\vec{B}$ is along $\hat{k}$]

$= 10nT\ (\cos 1.8y\ rad\ m^{-1} + 5.4 \times 10^6\ rad\ s^{-1})\ \hat{k}$

(42) **(A), (43) (B), (44) (C), (45) (D).**

(a) Given wavelength is of the order of 10^{-2}m i.e. short radio wave.

(b) $\lambda_m T = 0.29$ or $\lambda_m = \frac{0.29}{T} = \frac{0.29}{7} = 0.09cm$
$= 0.0009m.$
Wavelength is of the order of 10^{-4}m i.e., microwave.

(c) Given wavelengths are of the order of 10^{-7}m i.e., visible radiations (Yellow light)

(d) Using, $E = \frac{hc}{\lambda e}$ we get

$\lambda = \frac{hc}{Energy \times e} = \frac{(6.63\times10^{-34})(3\times10^8)}{(1.44\times10^3)(1.6\times10^{-19})}$

i.e., $\lambda = 0.86 \times 10^{-10} = 8.6 \times 10^{-11}$ m.
The wavelength of the order of 10^{-10}m corresponding to X-rays or soft γ-rays.