Electromagnetic Waves Important Questions With Answers

NEET Physics 2023

1. Green-house effect is the heating up of Earth's atmosphere due to
   a) green plants **b) infra-red rays** c) X-rays d) β-rays

   Solution : -

   Infrared ray is the cause of Green House effect. The glass transmits visible light while infrared rays are absorbed by plants. Then it emits long infrared rays, which are reflected back by glass.

2. An electromagnetic wave propagating along north has its electric field vector upwards. Its magnetic field vector point towards
   a) north **b) east** c) west d) downwards

3. About 6% of the power of a 100 W light bulb is converted to visible radiation. The average intensity of visible radiation at a distance of 8 m is (Assume that the radiation is emitted isotropically and neglect reflection.
   a) 3.5 x 10^{-3} W m^{-2} b) 5.1 x 10^{-3} W m^{-2} **c) 7.2 x 10^{-3} W m^{-2}** d) 2.3 x 10^{-3} W m^{-2}

   Solution : -

   Here, power of bulb = 100 W

   As intensity, I = $\frac{Power\ of\ visible\ light}{area}$

   = $\frac{100\times 6/100}{4\pi(8)^2} = 7.2\times 10^{-3} Wm^{-2}$

4. The part of the spectrum of the electromagnetic radiation used to cook food is
   a) ultraviolet rays b) cosmic rays c) X rays **d) microwaves**

   Solution : -

   Microwaves are used to cook food. Microwave oven is a domestic application of these waves.

5. The electric field part of an electromagnetic wave in vacuum is

   $E = 3.1\frac{N}{C} cos[(1.8\frac{rad}{m})y + (5.4\times 10^8\frac{rad}{s}t)]\hat{i}$. The wavelength of this part of electromagnetic wave is :
   a) 1.5 m b) 2 m c) 2.5 m **d) 3.5 m**

   Solution : -

   Given E = $3.1NC^{-1}\times cos[(1.8radm^{-1})y + (5.4\times 10^8 rads^{-1}t)t]\hat{i}$ ---- (i)

   Comparing (i) with the equation

   E = E_0 cos(ky+ωt)

   We get, k = 1.8 rad m^{-1},

   E0 =3.1 NC^{-1}, c = 3 x $10^8 ms^{-1}$,

   ωw = 5.4 x 108 rad s^{-1}

   Now, $\lambda = \frac{2\pi}{k} = \frac{2\times 22}{1.8\times 7} = 3.5m$

6. Radiations of intensity 0.5 W m^{-2} are striking a metal plate. The pressure on the plate is
   a) 0.166 x 10^{-8} N m^{-2} b) 0.332 x 10^{-8} N m^{-2} c) 0.111 x 10^{-8} N m^{-2} d) 0.083 x 10^{-8} N m^{-2}

   Solution : -

P= $\frac{I}{c} = \frac{0.5}{3 \times 10^8}$ =0.166 x 10^{-8} N m^{-2}

7. Which of the following is the longest wave?
   a) X-rays b) gamma-rays c) Microwaves **d) Radiowaves**

   Solution : -

   Wavelength range of various waves are as follows :

Name	Wavelength range (m)
Gamma rays	6×10^{-14} to 1×10^{-10}
X-rays	1×10^{-13} to 3×10^{-8}
Radio waves	greater than 0.1
Micro waves	10^{-3} to 0.3

   So, radiowaves are the longest waves.

8. Which among the following does not represent Maxwell's equation?
   a) $\oint \overrightarrow{E}.\overrightarrow{dA} = \frac{q}{\varepsilon_0}$ b) $\oint \overrightarrow{B}.\overrightarrow{dA} = 0$ **c)** $\oint \overrightarrow{E}.\overrightarrow{dl} = \frac{-dB}{dt}$ d) $\oint \overrightarrow{B}.\overrightarrow{dl} = \mu_0 I_C + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

   Solution : -

   Maxwell's equations are as follows

   (i) $\oint \overrightarrow{E}.\overrightarrow{dA} = \frac{q}{\varepsilon_0}$ (Gauss's law of electricity)

   (ii) $\oint \overrightarrow{B}.\overrightarrow{dA} = 0$ (Gauss's law of magnetism)

   (iii) $\oint \overrightarrow{E}.\overrightarrow{dl} = \frac{-dB}{dt}$ (Faraday's law)

   (iv) $\oint \overrightarrow{B}.\overrightarrow{dl} = \mu_0 I_C + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$ (Ampere - Maxwell law)

9. The ratio of amplitude of magnetic field to the amplitude of electric field for an electro-magnetic 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

   Solution : -

   In the electric field the average energy stored

   $U_E = \frac{1}{2}\varepsilon_0 E^2$

   In the magnetic field the average energy stored

   $= U_B = \frac{1B^2}{2\mu_0}$

   According to conservation of energy $U_E = U_B$

   $\varepsilon_0 \mu_0 = \frac{B^2}{E^2}$

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

10. **Assertion:** Electromagnetic waves exert radiation pressure.
    Reason: Electromagnetic waves carry energy.
    a) If both assertion and reason are true and reason is the correct explanation of assertion.

    b) If both assertionand reason are true but reason is not the correct explanation of assertion.

    c) If assertion is true but reason is false. d) If both assertion and reason are false.

    Solution : -

    Electromagnetic waves have linear momentum as well as energy. This concludes that they can exert radiation pressure by falling beam of electromagnetic radiation on an object.

11. An EM wave is propagating in a medium with a velocity $\vec{v} = v\hat{i}$. The instantaneous oscillating electric field of this EM wave is along +y axis. Then the direction of oscillating magnetic field of the em wave will be along:
a) - y direction **b) + z direction** c) - z direction d) - x direction

Solution : -

Now we see that $\vec{E} \times \vec{B} = \vec{v}$ shows the direction of propagation of waves

field direction is $\hat{i} = \hat{j} \times \hat{k}$

$v\hat{i} = \left(\vec{E}\right) \times \left(\vec{B}\right)$

Hence, $\vec{B} = B\hat{k}$, direction of propagation is along +z direction.

12. Which of the following electromagnetic wave play an important role in maintaining the earth's warmth or average temperature through the greenhouse effect?
a) Visible rays **b) Infrared waves** c) Gamma rays d) Ultraviolet rays

Solution : -

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 wayan average temperature is maintained.

13. If E and B denote electric and magnetic fields respectively, which of the following is dimensionless?
a) $\sqrt{\mu_0 \varepsilon_0}\,\frac{E}{B}$ b) $\mu_0 \varepsilon_0 \frac{E}{B}$ c) $\mu_0 \varepsilon_0 \left(\frac{B}{E}\right)^2$ d) $\frac{E}{\varepsilon_0}\frac{\mu_0}{B}$

Solution : -

Speed of light, c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$; Also , $\frac{E}{B}$ = c Therefore, $\sqrt{\mu_0 \varepsilon_0}\,\frac{E}{B}$ is dimensionless.

14. Light with an energy flux of 20 W/cm^2 falls on a non-reflecting surface at normal incidence. If the surface has an area of 30 cm^2, the total momentum delivered (for complete absorption) during 30 minutes is :
a) 36 x 10^{-5} kg m/s **b) 36 x 10^{-4} kg m/s** c) 108 x 10^{-4} kg m/s d) 1.08 x 10^7 kg m/s

Solution : -

For complete absorption, P = $\frac{U}{c}$

where U = Energy carried by light = IAt

$\therefore$ P = $\frac{IAt}{c}$

Here, 1= 20 W/cm^2, A = 30 cm^2, t = 30 min = 1800 s

so, P = $\frac{20 \times 30 \times 1800}{3 \times 10^8}$ = 36 x 10^{-4} kg m s^{-1}

15. The conduction current is same as displacement current when source is
a) ac only b) dc only **c) either ac or dc** d) neither dc nor ac

16. Suppose that the electric field amplitude of an electromagnetic wave propagating along x-direction is E_0 = 120 NC^{-1} and that its frequency is v = 50.0 MHz.
a) The expression of electric field is $\vec{E} = 120sin(\frac{\pi}{3}x - 100\pi \times 10^6 t)\hat{j}$
b) The expression of electric field is $\vec{E} = 60sin(\frac{\pi}{3}x - 100\pi \times 10^6 t)\hat{j}$
c) The expression of magnetic field is $\vec{B} = 40 \times 10^{-8} sin(\frac{\pi}{3}x - \pi \times 10^8 t)\hat{k}$ **d) Both (a) and (c)**

Solution : -

Since the wave is propagating along x-direction,

∴ Electric field $\vec{E}$ is along y - direction and magnetic field $\vec{B}$ along z-direction.

$\vec{E} = E_0 sin(kx - \omega t)\hat{j} = 120 sin(\frac{\pi}{3}x - 100\pi \times 10^6 t)\hat{j}$

$(\because k = \frac{2\pi}{\lambda} = \frac{2\pi v}{c} = \frac{2\pi \times 50 \times 10^6}{3 \times 10^8} = \frac{\pi}{3})$

$B_0 = \frac{E_0}{c} = \frac{120}{3 \times 10^8} = 40 \times 10^{-8} T$

$\vec{B} = B_0 sin(kx - \omega t)\hat{k} = 40 \times 10^{-8} sin(\frac{\pi}{3}x - \pi \times 10^8 t)\hat{k}$

17. The magnetic field of a beam emerging from a filter facing a flood light as given by B = 12 x 10^{-8} sin (1.20 x 10^7z - 3.60 x 10^{15} t) T. The average intensity of the beam is :

a) 1.71 W rn^{-2} b) 2.1 W m^{-2} c) 3.2 W m^{-2} d) 2.9 W m^{-2}

Solution : -

Here,

B = 12 x 10^{-8} sin (1.20 x 10^7 z -3.6 x 10^{15}t) T

Comparing it with, B = Bo sin (kz - ωt),

we have $B_0 = 12 \times 10^{-8} T$

$\therefore I_{av} = \frac{1}{2}\frac{B_0^2 c}{\mu_0} = \frac{1}{2} \times \frac{(12 \times 10^{-8})^2 \times 3 \times 10^8}{4\pi \times 10^{-7}}$

=1.71 W m^{-2}

18. Pick out the longest wavelength from the following types of radiation:

a) blue light b) gamma rays c) X-rays **d) red light**

Solution : -

The visible colors from shortest to longest wavelength are violet, blue, green, yellow, orange and red.

19. In the question 38, the amplitude of magnetic field part of the given wave is:

a) 2 x 10^{-8} T **b) 1.03 x 10^{-8} T** c) 4.22 x 10^{-8} T d) 5 x 10^{-8} T

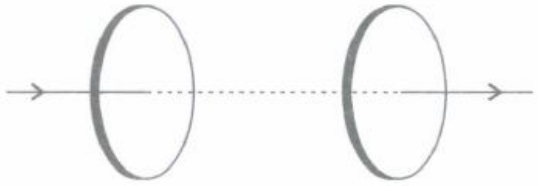
Solution : -

Comparing equation (i) and (ii) we get

E_0 = 3.1 N C^{-1}

$\therefore B_0 = \frac{E_0}{c} = \frac{3.1}{3 \times 10^8} = 1.03 \times 10^{-8} T$

20. A capacitor made of two circular plates each of radius 12 ern and separated by 5 mm. The capacitor is being charged by an external source. The charging current is constant and equal to 0.15 A. The capacitance of the parallel plate capacitor is



a) 40 pF b) 45 pF c) 70 pF **d) 80 pF**

Solution : -

Here, R = 12 cm = 0.12 m

d = 5 mm = 5 x 10^{-3} m, ε_0 = 8.85 X 10^{-12} C^2 N^{-1}m^{-2}

Also, A = πR^2 = 3.14 x (0.12)^2 m^2 = 4.5 x 10^{-2} m^2

Capacitance, C= $\frac{\varepsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 4.5 \times 10^{-2}}{5 \times 10^{-3}}$

=79.65*10^{-12}=80pF

21. Which of the following has/have zero average value in a plane electromagnetic wave?

a) Both magnetic and electric fields b) Electric field only c) Magnetic field only d) None of these

Solution : -

Both magnetic and electric fields have zero average value in a plane electromagnetic wave.

22. Ozone layer blocks the radiations of wave length_____

a) less than $3 \times 10^{-7}\ \mathrm{m}$ b) equal to $3 \times 10^{-7}\ \mathrm{m}$ c) more then $3 \times 10^{-7}\ \mathrm{m}$ d) All of the above

Solution : -

Ozone layer extends from 30 km to nearly 50 km above the earth's surface in ozone sphere. This layer absorbs the major part of ultraviolet radiations coming from the sun and does not allow them to reach the earth's surface. The range of ultraviolet radiations is 100 A^o to 4000 A^o. Thus, it blocks the radiations of wavelength less than $3 \times 10^{-7}\ \mathrm{m}$(or 3000 A^o).

23. The electric field of a plane electromagnetic wave varies with time of amplitude 2 Vm^{-1} propagating along z-axis. The average energy density of the magnetic field (in J m^{-3}) is :

a) 13.29 x 10^{-12} **b) 8.86 x 10^{-12}** c) 17.72 x 10^{-12} d) 4.43 x 10^{-12}

Solution : -

Amplitude of electric field and magnetic field are related by the relation $\frac{E_0}{B_0}$=c

Average energy density of the magnetic field is $U_B = \frac{1}{4}\ \frac{B_0^2}{\mu_0}$ =$\frac{1}{4}\ \frac{E_0^2}{\mu_0 c^2}\ \left(\because B_0 = \frac{E_0}{c}\right)$

=$\frac{1}{4}\ \varepsilon_0\ E_0^2\ \left(\because c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}\right)$

$= \frac{1}{4}$ x 8.854 x 10^{-12} x (2)^2 = 8.854 x 10^{-12} J m^{-3}

= 8.86 x 10^{-12} J m^{-3}

24. Which of the following is the infrared wavelength?

a) 10^{-4} cm b) 10^{-5} cm c) 10^{-6} cm d) 10^{-7} cm

Solution : -

Since, infrared wavelength starts from 7500Å

So,7500Å = 7500 x 10^{-10} m = 0.75 x 10^{-6}m

= 0.75 X 10^{-4}cm

≈1.0 X 10^{-4} cmÅ

25. 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 vector's

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

Solution : -

Electromagnetic waves are the combination of mutually perpendicular electric and magnetic fields.

26. Which of the following rays is not an electromagnetic wave?

a) X-rays b) γ-rays **c) β-rays** d) α-rays

27. A microwave and an ultrasonic sound wave have the same wavelength. Their frequencies are in the ratio (approximately)

a) 10^2 b) 10^4 **c) 10^6** d) 10^8

Solution : -

Frequency of microwaves, $v_m \approx 10^{11}$ Hz

Frequency of ultrasonic sound waves, $v_u \approx 10^5$Hz

$\therefore \frac{v_m}{v_u} = \frac{10^{11}}{10^5} = 10^6$

28. The photon energy in units of eV for electromagnetic waves of wavelength 2 cm is :

a) 2.5 x 10^{-19} b) 5.2 x 10^{16} c) 3.2 x 10^{-16} **d) 6.2 x 10^{-5}**

Solution : -

As, E = $\frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{2 \times 10^{-2}}$ = 9.9 x 10^{-24} J

$\frac{9.9 \times 10^{-24}}{1.6 \times 10^{-19}}$ eV = 6.2 x 10^{-5} eV

29. If λ_2, λ_x and λ_m represent the wavelengths of visible light, X-rays and microwaves respectively, then _____

a) $\lambda_{\mathrm{m}} > \lambda_x > \lambda_v$ **b)** $\lambda_m > \lambda_v > \lambda_r$ c) $\lambda_{\mathrm{v}} > \lambda_{\mathrm{x}} > \lambda_w$ d) $\lambda_v > \lambda_w > \lambda_{x_x}$

Solution : -

As we know, $E = \frac{hc}{\lambda} \Rightarrow E \propto \frac{1}{\lambda}$

$\Rightarrow E_m < E_v < E_x$

$\therefore \lambda_m > \lambda_v > \lambda_x$

30. A. Wavelength of microwaves is greater than that of ultraviolet rays.

B. The wavelength of infrared rays is lesser than that of ultraviolet rays.

C. The wavelength of microwaves is lesser than that of infrared rays

D. Gamma ray has shortest wavelength in the electromagnetic spectrum

Choose the correct option.

a) A and B are true b) B and C are true c) C and D are true **d) A and D are true**

31. Assume a bulb of efficiency 2.5% as a point source. The peak values of electric and magnetic fields produced by the radiation coming from a 100 W bulb at a distance of 3 m is respectively

a) 2.5 V m^{-1}, 3.6 x 10^{-8} T b) 4.2 V m^{-1}, 2.8 x 10^{-8} T **c) 4.08 V m^{-1}, 1.36 x 10^{-8} T** d) 3.6 V m^{-1}, 4.2 x 10^{-8} T

Solution : -

Here intensity, I=$\frac{power}{area}$

=$\frac{100 \times 2.5}{4\pi(3)^2 \times 100} = \frac{2.5}{36\pi} W m^{-2}$

Half of this intensity belongs to electric field and half of that to magnetic field.

$\therefore \frac{I}{2} = \frac{1}{4}\epsilon_0 E_0^2 c$

or $E_0 = \sqrt{\frac{2I}{\epsilon_0 c}} = \sqrt{\frac{2 \times \frac{2.5}{36\pi}}{\frac{1}{4\pi \times 9 \times 10^9} \times 3 \times 10^8}} = 4.08 V m^{-1}$

$\therefore B_0 = \frac{E_0}{c} = \frac{4.08}{3 \times 10^8} = 1.36 \times 10^{-8} T$

32. X-rays and γ-rays of same energies are distinguished by their

a) frequency b) charges c) ionising power **d) method of production**

33. Light with an energy flux of 18 W cm^{-2} falls on a non-reflecting surface at normal incidence. If the surface has an area of 20 cm^2, the average force exerted on the surface during a 30 minute time span is :

a) 2.1 x 10^{-6} N **b) 1.2 x 10^{-6} N** c) 1.2 x 10^6 N d) 2.1 x 10^6 N

Solution : -

The total energy falling on the surface is U = 18 x 20 x (30 x 60) = 6.48 x 10^5 J Therefore, the total momentum delivered (for complete absorption is)

P = $\frac{U}{c} = \frac{6.48 \times 10^5}{3 \times 10^8}$ = 2.16 x 10^{-3} kg m s^{-1}

The average force exerted on the surface is F = $\frac{P}{t} = \frac{2.16 \times 10^{-3}}{0.18 \times 10^4}$ = 1.2 x 10^{-6} N

34. A signal emitted by an antenna from a certain point can be received at another point of the surface in the form of _____ .

a) sky wave b) groúnd wave c) sea wave **d) Both (a) and (b)**

Solution : -

Space communication refers to sending, receiving and processing of information through space. Following are the modes of space communication,

(i) Ground or surface wave propagation

(ii) Space wave or tropospheric wave propagation

(iii) Sky wave propagation

(iv) Satellite communication

35. **Assertion:** If earth did not have atmosphere, its average surface temperature would be lower than what it is now.
Reason : Green house effect of the atmosphere would be absent, if earth did not have atmosphere.
a) If both assertion and reason are true and reason is the correct explanation of assertion.

b) If both assertionand reason are true but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false. d) If both assertion and reason are false.

Solution : -

The radiation of infrared rays of sun keep the earth's surface warm even at night due to the green house effect of the atmosphere. Heavy gases like CO_2 present in earth's atmosphere reflect infra-red radiation back towards the earth's surface. Due to which earth's atmosphere becomes richer in infrared radiation. If atmosphere is absent then earth temperature falls off.

36. **Assertion:** One should not use metal containers in a microwave oven.
Reason : Only because metal may melt from heating.
a) If both assertion and reason are true and reason is the correct explanation of assertion.

b) If both assertionand reason are true but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false. d) If both assertion and reason are false.

Solution : -

One should use porcelain vessels and not metal containers in a microwave oven because of the danger of getting a shock from accumulated electric charges. Metal may also melt from heating.

37. An electromagnetic wave of frequency v=3.0 MHz passes from vacuum into a dielectric medium with relative permittivity $\varepsilon = 4.0$. Then_____

a) wavelength is doubled and frequency is unchanged b) wavelength is doubled and frequency becomes half
c) wavelength is halved and frequency remains unchanged
d) wavelength and frequency both remain unchanged

Solution : -

Given: frequency $f = 2\text{MHz}$, relative permittivity $E_r = 4$.

From formula,

velocity $v = \frac{c}{\sqrt{E_r}} = \frac{c}{2} \Rightarrow \lambda' = \frac{\lambda}{2}$

[As we know frequency remains unchanged]

38. Displacement current goes through the gap between the plates of a capacitor when the charge on the capacitor
a) is changing with time b) decreases c) does not change d) decreases to zero

Solution : -
Displacement current arises when electric field in a region is changing with time. It will be so if the charge on a capacitor is changing with time.

39. The velocity of electromagnetic radiation in a medium of permittivity e_0 and permeability m_0 is given by_____
a) $\sqrt{\frac{\epsilon_0}{\mu_0}}$ b) $\sqrt{\mu_0 \in_0}$ **c)** $\frac{1}{\sqrt{\mu_0 \in_0}}$ d) $\sqrt{\frac{\mu_0}{\epsilon_0}}$

Solution : -
The velocity of electromagnetic radiation $= \frac{1}{\sqrt{\mu_0 \in_0}}$

40. We consider the radiation emitted by the human body. Which of the following statements is true?
a) the radiation emitted lies in the ultraviolet region and hence is not visible
b) the radiation emitted is in the infra-red region c) the radiation is emitted only during the day
d) the radiation is emitted during the summers and absorbed during the winters

Solution : -
Depends on the magnitude of frequency

41. A plane electromagnetic wave travels in vacuum along z-direction, If the frequency of the wave is 40 MHz then its wavelength is
a) 5 m **b) 7.5 m** c) 8.5 m d) 10 m

Solution : -
Wavelength, $\lambda = \frac{c}{\upsilon} = \frac{3 \times 10^8\ ms^{-1}}{40 \times 10^6\ s^{-1}}$ = 7.5 m

42. The refractive index and permeability of a medium are 1.5 and 5×10^{-7} H m^{-1} respectively. The relative permittivity of the medium is nearly
a) 25 b) 15 c) 10 **d) 6**

Solution : -
Refractive index, $n = \frac{c}{v}$
or $v = \frac{c}{\upsilon} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8$ m s^{-1}
Here $\mu = 5 \times 10^{-7}$ H m^{-1}
$\therefore\ v = \frac{1}{\sqrt{\mu\varepsilon}} = \frac{1}{\sqrt{\mu\varepsilon_0\varepsilon_r}}$
$\varepsilon_r = \frac{1}{v^2\mu\varepsilon_0} = \frac{1}{\left(2\times10^8\right)^2 \times \left(5\times10^{-7}\right) \times \left(8.85\times10^{-12}\right)} = 5.65 \simeq 6$

43. The charge on a parallel plate capacitor varies as $q = q_0 \cos \pi\upsilon t$. The plates are very large and close together (area = A, separation = d). The displacement current through the capacitor is
a) $q_0\, 2\pi\upsilon \sin \pi\upsilon t$ **b) $-q_0\, 2\pi\upsilon$ sin2 $\pi\upsilon t$** c) $q_0\, 2\pi \sin \pi\upsilon t$ d) $q_0\, \pi\upsilon \sin 2\pi\upsilon t$

Solution : -
I_D = conduction current, I_C
$\therefore\ \frac{dq}{dt} = \frac{d}{dt}[q_0 \cos 2\pi\upsilon t] = -q_0\, 2\pi\upsilon \sin 2 \pi\upsilon t$

44. Which of the following statement is wrong?
a) Infrared photon has more energy than the photon of visible light
b) Photographic plates are sensitive to ultraviolet rays
c) Photographic plates can be made sensitive to infrared rays
d) Infrared rays are invisible but can cast shadows like visible light rays

Solution : -

Since, $E = \frac{hc}{\lambda}$ and $\lambda_{IR} > \lambda_{isible}$

So, EIR < $E_{visible}$

Hence, option (a) is incorrect.

45. Sea water at frequency D = 4 X 10^8 Hz has permittivity ε = 80 ε_0, permeability μ≈μ_0 and resistivity p = 0.25 Ω-m. Imagine a parallel plate capacitor immersed in sea water and driven by an alternating voltage source V(t) = V_o sin (z_{π}vt). The ratio of amplitude of the conduction current density to the displacement current density is

a) 2/3 **b) 4/9** c) 9/4 d) 2

Solution : -

V(t) = V_0 sin 2_{π}vt

Let distance between the plates = d.

Electric field = $\frac{V(t)}{d} = \frac{V_0}{d} sin2\pi vt$

Conduction current density

$J_c = \frac{E}{\rho} = \frac{V_0}{\rho d} sin2\pi vt = J_{0_c} sin2\pi vt$

where J_{0c} is maximum conduction current density.

Displacement current density,

$J_d = \epsilon \frac{d}{dt}[\frac{V_0}{d} sin(2\pi vt)] = \frac{2\pi v\epsilon}{d} V_0 cos2\pi vf$

$J_d = J_{0_d} cos(2\pi vf)$

$\frac{J_{0_d}}{J_{0_c}} = \frac{2\pi v}{V_0}\epsilon\frac{V_0}{d} = 2\pi v\epsilon\rho = 2\pi(4\times10^8)(80\epsilon_0)(0.25)$

$= \frac{J_{0_c}}{J_{0_d}} = \frac{9\times10^9}{4\times10^9} = \frac{9}{4} \quad (\frac{1}{4\pi\epsilon_0} = 9\times10^9 Nm^2/C^2)$

46. A plane electromagnetic wave propagating along x direction can have the following pairs of $\vec{E}$ and $\vec{B}$

a) E_y, B_z b) E_z, B_y c) E_x, B_y d) both (a) and (b)

Solution : -

As electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ are perpendicular to each other as well as perpendicular to the direction of propagation of electromagnetic wave.Hence options (a) and (b) are correct.

47. The electric field of an electromagnetic wave travelling through vacuum is given by the equation E = E_o sin (kx - ωt). The quantity that is independent of wavelength is

a) kω **b)** $\frac{k}{\omega}$ c) $k^2\omega$ d) ω

Solution : -

Here, k=$\frac{2\pi}{\lambda}$. $\omega = 2\pi v$

$\therefore \frac{k}{\omega} = \frac{2\pi/\lambda}{2\pi v} = \frac{1}{v\lambda} = \frac{1}{c}$ (∵ c = uλ)

where e is the speed of electromagnetic wave in vacuum.

It is a constant whose value is 3 x 10^8 ms^{-1}.

48. The frequency of y-rays, X-rays and ultraviolet rays are a, band c respectively, then

a) a < b > c b) a > b > c c) a> b < c d) a < b < c

Solution : -

The frequency of radiations of waves are:

	Waves	**Frequency (in Hz)**
1.	γ -.rays	3 X 10^{21} to 3 X 10^{18}(a)
2.	X-rays	3 X 10^{12} to 3 X 10^{16} (b)
3.	Ultraviolet radiation	3 x 10^{16} to 7.5 X 10^{14} (c)

Hence correct order is a > b > c

49. A plane electromagnetic wave of frequency 25 MHz travels in free space along x-direction. At a particular point in space and time, electric field E = 6.3 V m^{-1}. The magnitude of magnetic field B at this point is :

a) 1.2 x 10^{-6} T b) 1.2 x 10^{-8} T c) 2. 1 x 10^{-6} T **d) 2.1 x 10^{-8} T**

Solution : -

As, B = $\frac{E}{c} = \frac{6.3}{3 \times 10^{-8}}$ = 2.1 x 10^{-8} T

50. 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 x 10^{-8} T **b) 2.83 x 10^{-8} T** c) 0.70 x 10^{-8} T d) 4.23 x 10^{-s} T

Solution : -

The rms value of magnetic field

$B_{rms} = E_{rm}/c = 6/(3 \text{ X } 10^8) = 2 \text{ x } 10^{-8}$

Now peak value of magnetic field

$B_{peak} = E_{rms}/c = 6/(3 \times 10^8) = 2 \times 10^{-8} T$