Electromagnetic Waves

1. An ac source is connected to a capacitor C. Due to decrease in its operating frequency: **(2023)**
   (a) Capacitive reactance remains constant
   (b) Capacitive reactance decreases.
   (c) Displacement current increases.
   (d) Displacement current decreases.

2. In a plane electromagnetic wave travelling in free space, the electric field component oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude 48 Vm^{-1}. Then the amplitude of oscillating magnetic field is: **(2023)**
   (Spped of light in free space = $3 \times 108\, ms^{-1}$)
   (a) $1.6 \times 10^{-6}\, T$
   (b) $1.6 \times 10^{-9}\, T$
   (c) $1.6 \times 10^{-8}\, T$
   (d) $1.6 \times 10^{-7}\, T$

3. Match Lis –I with List –II

	List-I (Electromagnetic wave)		List-II (Wavelength)
(A)	AM radio waves	(i)	10^{-10} m
(B)	Microwaves	(ii)	10^{2} m
(C)	Infrared radiations	(iii)	10^{-2} m
(D)	X-rays	(iv)	10^{-4} m

   Choose the correct answer from the options given below: **(2022)**
   (a) (A) – (iii), (B) – (ii), (C) – (i), (D) – (iv)
   (b) (A) – (iii), (B) – (iv), (C) – (ii), (D) – (i)
   (c) (A) – (ii), (B) – (iii), (C) – (iv), (D) – (i)
   (d) (A) – (iv), (B) – (iii), (C) – (ii), (D) – (i)

4. When light propagates through a material medium of relative permittivity ϵ, and relative permeability μ_r, the velocity of light, v is given by : (c-velocity of light in vaccum) **(2022)**
   (a) $v = \sqrt{\frac{\mu_r}{\epsilon_r}}$
   (b) $v = \sqrt{\frac{\epsilon_r}{\mu_r}}$
   (c) $v = \frac{c}{\sqrt{\epsilon_r \mu_r}}$
   (d) $v = c$

5. 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? **(2021)**
   (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) $\hat{j} + \hat{k}, \hat{j} + \hat{k}$

6. The ratio of contributions made by the electric field and magnetic field components to the intensity of an electromagnetic wave is : (c = speed of electromagnetic waves) **(2020)**
   (a) 1 : 1
   (b) 1 : c
   (c) 1 : c^2
   (d) c : 1

7. The magnetic field in a place electromagnetic wave is given by,
   $B_y = 2 \times 10^{-7} \sin(\pi \times 10^3 x + 3\pi \times 10^{11} t)\, T$
   Calculate the wavelength. **(2020 Covid Re-NEET)**
   (a) $2 \times 10^{-3} m$
   (b) $2 \times 10^{3} m$
   (c) $\pi \times 10^{-3} m$
   (d) $\pi \times 10^{3} m$

8. The E.M. wave with shortest wavelength among the following is, **(2020 Covid Re-NEET)**
   (a) X-rays
   (b) Gamma-rays
   (c) Microwaves
   (d) Ultraviolet rays

9. Which colour of the light has the longest wavelength?
   (a) Red
   (b) Blue
   (c) Green
   (d) Violet

10. A parallel plate capacitor of capacitance 20 μF 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. **(2019)**
    (a) Zero, 60 μA

(b) 60 μA, 60 μA
(c) 60 μA, zero
(d) Zero, zero

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. **(2018)**
(a) –y direction
(b) +z direction
(c) –z direction
(d) –x direction

12. 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: **(2017-Delhi)**
(a) $2.83 \times 10^{-8} T$
(b) $0.70 \times 10^{-8} T$
(c) $4.23 \times 10^{-8} T$
(d) $1.41 \times 10^{-8} T$

13. Out of the following options which one can be used to produce a propagating electromagnetic wave? **(2016-I)**
(a) A charge moving at constant velocity
(b) A stationary charge
(c) A charge less particle
(d) An accelerating charge

14. Radiation of energy 'E' falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (C = velocity of light): **(2015)**
(a) $2E/C$
(b) $2E/C^2$
(c) E/C^2
(d) E/C

15. The energy of the E.M. waves is of the order of 15 keV. To which part of the spectrum does it belong? **(2015 Pre)**
(a) Gamma-rays
(b) X-rays
(c) Infra-red rays
(d) Ultraviolet rays

16. Light with an energy flux of $25 \times 10^4 W/m^2$ falls on a perfectly reflecting surface at normal incidence. If the surface area is 15 cm2, the average force exerted on the surface is: **(2014)**
(a) 1.25×10^{-6} N
(b) 2.50×10^{-6} N
(c) 1.20×10^{-6} N
(d) 3.0×10^{-6} N

17. The condition under which a microwave oven heats up a food item containing water molecules most efficiently is: **(2013)**
(a) Infra-red waves produce heating in a microwave oven
(b) The frequency of the microwaves must match the resonant frequency of the water molecules
(c) The frequency of the microwaves has no relation with natural frequency of water molecules
(d) Microwaves are heat waves, so always produce heating

Answer Key

S1. Ans. (d)

S2. Ans. (d)

S3. Ans. (c)

S4. Ans. (c)

S5. Ans. (a)

S6. Ans. (a)

S7. Ans. (a)

S8. Ans. (b)

S9. Ans. (a)

S10. Ans. (b)

S11. Ans. (b)

S12. Ans. (a)

S13. Ans. (d)

S14. Ans. (a)

S15. Ans. (b)

S16. Ans. (b)

S17. Ans. (b)

Solutions

S1. Ans.(d)

Capacitive reactance $= \frac{1}{\omega C} = X_c$ (say)

On decreasing the operating frequency ω reduces As X_c is inversely proportional to ω the value of X_c increase

$\therefore I_C = I_D$

$= \frac{V_0}{X_c}$

As X_c increases, therefore displacement current Id decreases.

S2. Ans.(d)

$B = \frac{E}{C} = \frac{48}{3\times10^8} = 16 \times 10^{-8}$

$= 1.6 \times 10^{-7} T$

S3. Ans.(c)

(A) Radio wave (ii) $\approx 10^2 m$ (ii)

(B) Microwave $\approx$ (iii) $10^{-2} m$ (iii)

(C) Infrared radiations $\approx$ (iv) $10^{-4} m$ (iv)

(D) X-ray (i) $\approx$ Å = $10^{-10} m$ (i)

(A) – (ii), (B) – (iii), (C) – (iv), (D) – (i)

S4. Ans.(c)

$n = \sqrt{\epsilon_r \mu_r}$

$n = \frac{c}{v} \Rightarrow v = \frac{c}{n}$

$v = \left(\frac{c}{\sqrt{\epsilon_r \mu_r}}\right)$

S5. Ans.(a)

$c = \vec{E} \times \vec{B}$

$\left(-\hat{j} + \hat{k}\right) \times \left(-\hat{j} - \hat{k}\right)$

$= \hat{\imath} + \hat{\imath}$

$= 2\hat{\imath}$

S6. Ans.(a)

In EMW, electric field and magnetic field have same energy density and same intensities.

S7. Ans.(a)

Wavelength $(\lambda) = \frac{2\pi}{k} = \frac{2\pi}{\pi\times10^3}$

$\Rightarrow \lambda = 2 \times 10^{-3} m$

S8. Ans.(b)

Gamma rays has the shortest wavelength among the given options of E.M waves

S9. Ans.(a)

Red has the longest wavelength while violet has smallest wavelength among the given options.

S10. Ans.(b)

Given capacitance of capacitor C = 20 μF

$= 20 \times 10^{-6} F$

Rate of change of potential $\left(\frac{dV}{dt}\right) = 3V/s$

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

$i_c = 20 \times 10^{-6} \times 3 = 60 \times 10^{-6} A = 60\mu A$

Also $i_d = i_c = 60\mu A$

S11. Ans.(b)

Direction $(\vec{v})$ is decided by $\vec{E} \times \vec{B}$

$\vec{V} = \vec{E} \times \vec{B}$

$\hat{\imath} = \hat{\jmath} \times \hat{B}$

$\hat{B} = \hat{k} = +z$ direction

S12. Ans.(a)

$E_{rms} = \frac{E_0}{\sqrt{2}}$

$E_0 = \sqrt{2} E_{rms}$

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

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

$B_0 = \frac{E_0}{C} = \frac{6\sqrt{2}V/m}{3\times10^8\ m/s}$

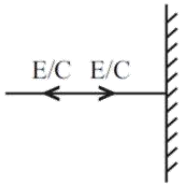
$B_0 = 2.824 \times 10^{-8} T$

S13. Ans.(d)

To generate electromagnetic waves we need accelerating charge particle

S14. Ans.(a)

Momentum of light $p = \frac{E}{C}$



So, momentum transferred to the surface

$= p_f - p_i = \frac{2E}{C}$

S15. Ans.(b)

Wavelength of the way

$\lambda = \frac{hc}{E}$

$= 0.826Å$

γ	X-ray	UV
$10^{-2}Å$	$1Å$	$3 \times 10^{-7}m$

Since $10^{-3}nm \leq \lambda \leq 1\,mm$

So, it is X-ray

S16. Ans.(b)

Average force $F_{av} = \frac{\Delta p}{\Delta t} = \frac{2\phi A}{c}$

$= \frac{2\times25\times10^{4}\times15\times10^{-4}}{3\times10^{8}}$

$= 2.50 \times 10^{-6}\text{N}$

S17. Ans.(b)

The frequency of microwave must match the resonant frequency of the water molecules in the food.