Electromagnetic Waves JEE Main PYQ - 3

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Electromagnetic Waves

1. If a source of electromagnetic radiation having power $15kW$ produces 10^{16} photons per second, the radiation belongs to a part of spectrum is(Take Planck constant $h = 6 \times 10^{-34} Js$) **(+4, -1)**

[11 Jan 2019, I]

a. Micro waves

b. Radio waves

c. Gamma rays

d. Ultraviolet rays

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2. Match List I with List II **(+4, -1)**

List I		List II	
A.	Microwaves	I.	Physiotherapy
B.	UV rays	II.	Treatment of cancer
C.	Infra-red rays	III.	Lasik eye surgery
D.	X-rays	IV.	Aircraft navigation

Choose the correct answer from the options given below:

[27-Jun-2022-Shift-1]

a. A - IV, B - I, C - II, D - III

b. A - II, B - IV, C - III, D - I

c. A - IV, B - III, C - I, D - II

d. A - III, B - II, C - I, D - IV

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3. An electromagnetic wave is transporting energy in the negative z direction At a certain point and certain time the direction of electric field of the wave is along positive y direction What will be the direction of the magnetic field of the wave at that point and instant? **(+4, -1)**

[25-Jan-2023 Shift1]

a. Positive direction of z

b. Negative direction of y

c. Positive direction of x

d. Negative direction of x

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4. In $\vec{E}$ and $\vec{K}$ represent electric field and propagation vectors of the EM waves in vacuum, then magnetic field vector is given by:($\omega-$ angular frequency): **(+4, -1)**

[24-Jan-2023 Shift1]

a. $\frac{1}{\omega}(\vec{K} \times \vec{E})$

b. $\omega(\vec{E} \times \vec{K})$

c. $\vec{K} \times \vec{E}$

d. $\omega(\vec{K} \times \vec{E})$

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5. The electric field and magnetic field components of an electromagnetic wave going through vacuum is described by $E_x = E_o \sin(kz - \omega t)$ $B_y = B_0 \sin(kz - \omega t)$ Then the correct relation between E_0 and B_0 is given by **(+4, -1)**

[24-Jan-2023 Shift2]

a. $E_0 B_0 = \omega k$

b. $E_0 = kB_0$

c. $kE_0 = \omega B_0$

d. $\omega E_0 = kB_0$

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6. In a medium the speed of light wave decreases to 0.2 times to its speed in free space The ratio of relative permittivity to the refractive index of the medium is $x : 1$ The value of x is(Given speed of light in free space $= 3 \times 10^8 ms^{-1}$ and for the given medium $\mu = 1$) **(+4, -1)**

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7. Light wave travelling in air along x-direction is given by $E_y = 540 \sin \pi \times 10^4 (x - ct) V m^{-1}$ Then, the peak value of magnetic field of wave will be (Given **(+4, -1)**

$c = 3 \times 10^8 ms^{-1}$)

[25-Jul-2022-Shift-2]

a. $18 \times 10^{-7} T$

b. $54 \times 10^{-7} T$

c. $54 \times 10^{-8} T$

d. $18 \times 10^{-8} T$

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8. Match the list-I with list-II and choose the correct option. **(+4, -1)**

	List-I		List-II
(A).	Microwave	(P).	1 nm - 400nm
(B).	Ultraviolet	(Q).	1 nm - 1nm
(C).	X-rays	(R).	2.5 μm - 750nm
(D).	Infrared	(S).	1 μm - 1nm

a. A-(s), B-(q), C-(r), D-(p)

b. A-(s), B-(p), C-(q), D-(r)

c. A-(p), B-(s), C-(q), D-(r)

d. A-(r), B-(q), C-(s), D-(p)

[15-Apr-2023 shift 1]

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9. Which of the following is the highest electromagnetic wave? **(+4, -1)**

a. X-ray

[Online April 12, 2014]

b. Infrared

c. Microwaves

d. Radiowave

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10. The ratio of average electric energy density and total average energy density of electromagnetic wave is: **(+4, -1)**

[1-Feb-2023 Shift 2]

a. 2

b. 3

c. $\frac{1}{2}$

d. 1

Answers

1. **Answer: c**

Explanation:

$$\text{Energy of one photon} = \frac{\text{Power}}{\text{Photon frequency}}$$

$E = hv = \frac{15\times10^{3}}{10^{16}}$

$v = \frac{15\times10^{-13}}{6\times10^{-34}} = 2.5 \times 10^{21}$

So gamma Rays. Option 3

Concepts:

1. Electromagnetic waves:

The waves that are produced when an electric field comes into contact with a magnetic field are known as Electromagnetic Waves or EM waves. The constitution of an oscillating magnetic field and electric fields gives rise to electromagnetic waves.

Types of Electromagnetic Waves:

Electromagnetic waves can be grouped according to the direction of disturbance in them and according to the range of their frequency. Recall that a wave transfers energy from one point to another point in space. That means there are two things going on: the disturbance that defines a wave, and the propagation of wave. In this context the waves are grouped into the following two categories:

- **Longitudinal waves:** A wave is called a longitudinal wave when the disturbances in the wave are parallel to the direction of propagation of the wave. For example, sound waves are longitudinal waves because the change of pressure occurs parallel to the direction of wave propagation.
- **Transverse waves:** A wave is called a transverse wave when the disturbances in the wave are perpendicular (at right angles) to the direction of propagation of the wave.

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2. **Answer: c**

Explanation:

The correct answer is (C) : A - IV, B - III, C - I, D - II

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3. Answer: c

Explanation:

As, poynting vector
$\vec{S} = \vec{E} \times \vec{H}$
Given energy transport $=$ negative z direction
Electric field $=$ positive y direction
$(-\hat{k}) = (+\hat{j}) \times [\hat{i}]$

Hence according to vector cross product magnetic field should be positive x direction.

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4. Answer: a

Explanation:

The correct answer is (A) :$\frac{1}{\omega}(\vec{K} \times \vec{E})$
Magnetic field vector will be in the direction of $\hat{K} \times \hat{E}$
magnitude of $B = \frac{E}{C} = \frac{K}{\omega}E$
Or $\overrightarrow{B} = \frac{1}{\omega}(\overrightarrow{K} \times \overrightarrow{E})$

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5. **Answer: c**

Explanation:

The correct answer is (C) : $kE_0 = \omega B_0$
$C = \frac{\omega}{k} = \frac{E_0}{B_0}$

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6. **Answer: 5 - 5**

Explanation:

The correct answer is 5.

$V = \frac{C}{\mu} \Rightarrow \mu = \frac{C}{V} = \frac{C}{0.2C}$

$\mu = 5$

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

$\Rightarrow \epsilon_r = \frac{\mu^2}{\mu_r}$

$\therefore \frac{\epsilon_r}{\mu} = \frac{\mu}{\mu_r} = 5$

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7. **Answer: a**

Explanation:

$$E_y = 540 \sin \pi \times 10^4 (x - ct) V m^{-1}$$
$$E_0 = 540 V m^{-1}$$
$$B_0 = \frac{E_0}{C} = \frac{540}{3 \times 10^8} = 18 \times 10^{-7} T$$

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8. **Answer: a**

Explanation:

The Correct answer is (B). A-(s), B-(p), C-(q), D-(r)

Concepts:

1. **Electromagnetic Spectrum:**

The term used by scientists to describe the entire range of light that exists is the **electrostatic spectrum**. Light is a wave of alternating electric and magnetic fields. The propagation of light doesn't vary from waves crossing an ocean. Like any other wave, light also has a few fundamental properties that describe it. One is its frequency. The frequency is measured in Hz, which counts the number of waves that pass by a point in one second.

The electromagnetic waves that your eyes detect are visible light and oscillate between 400 and 790 terahertz (THz). That's several hundred trillion times a second.

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9. **Answer: a**

Explanation:

X-rays have higher frequencies and shorter wavelengths compared to the other options listed. As electromagnetic waves, they are situated in the high-frequency end of the electromagnetic spectrum, above ultraviolet light. Therefore, X-rays have more energy and higher electromagnetic frequencies compared to infrared, microwaves, and radio waves.

So, the correct option is (A): X-rays.

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10. **Answer: c**

Explanation:

$< u_E >=< u_B >= \frac{1}{2} < u_{\text{total}} >$
So $\frac{\langle u_E \rangle}{\langle u_{\text{total}} \rangle} = \frac{1}{2}$

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