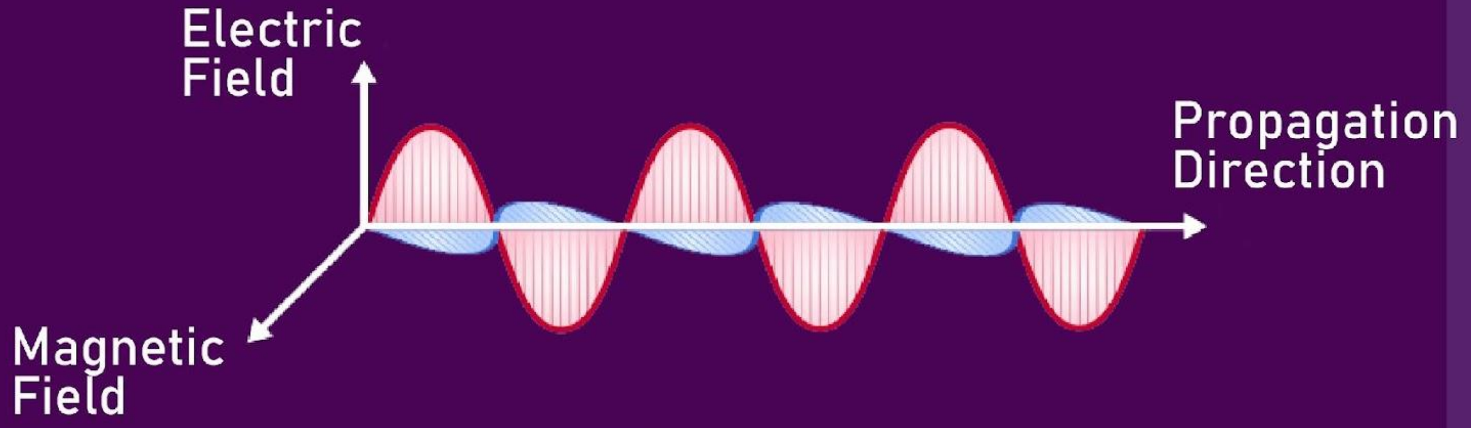
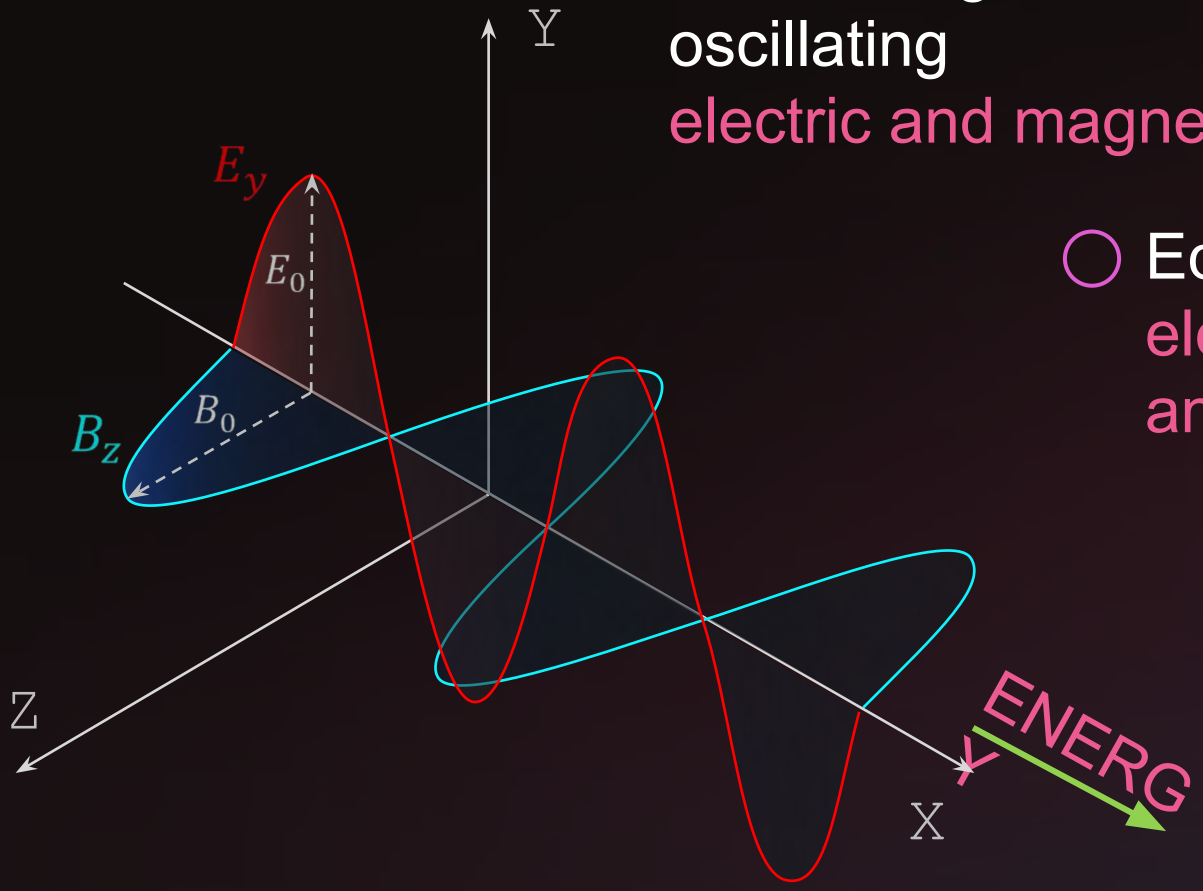
ELECTROMAGNETIC WAVES - L3



PHYSICS

https://t.me/neetaakashdigital

waves



- Electromagnetic waves carry energy in oscillating electric and magnetic field.

- Equal amount of energy is contributed by electric and magnetic field.

FIELD

FIELD

$$U = \frac{1}{2} C V^2$$

$$V = \vec{E} . \vec{d} = E d \cos 0° = E d$$

$$U = \frac{1}{2} \frac{\epsilon_0 A}{d} (E d)^2$$

$$U = \frac{1}{2} \epsilon_0 E^2 A d$$

$$U = \frac{1}{2} \epsilon_0 E^2 (Vol.)$$

$$\frac{U}{Vol.} = \frac{1}{2} \epsilon_0 E^2$$

$$\mu_E = \frac{1}{2} \epsilon_0 E^2$$

DENSITY OF ELECTRIC FIELD

$$\mu_E = \frac{1}{2}\epsilon_0 E^2$$

$$E = E_0 \sin(Kx - \omega t)$$

DENSITY OF ELECTRIC FIELD

$$\mu_E = \frac{1}{2}\epsilon_0 E^2 \qquad E = E_0 \sin(Kx - \omega t)$$

$$\mu_E = \frac{1}{2}\epsilon_0 E_0^2 \sin^2(Kx - \omega t)$$

$$\overline{\mu_E} = \frac{1}{2}\epsilon_0 E_0^2 \overline{\sin^2(Kx - \omega t)}$$

$$\overline{\mu_E} = \frac{1}{2}\epsilon_0 E_0^2 \times \frac{1}{2}$$

$$(\mu_E)_{avg} = \frac{1}{4}\epsilon_0 E_0^2$$

FIELD

FIELD

$$U = \frac{1}{2} L i^2$$

$$L = \mu_0 n^2 A l \quad \text{and} \quad i = \frac{B}{\mu_0 n}$$

n = no. of turns per unit length

$$B = \mu_0 n i$$

$$U = \frac{1}{2} \mu_0 n^2 A l \times \frac{B^2}{\mu_0^2 n^2}$$

$$U = \frac{1}{2} \frac{B^2}{\mu_0} A l$$

$$\frac{U}{Vol.} = \frac{1}{2} \frac{B^2}{\mu_0}$$

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

DENSITY OF MAGNETIC FIELD

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

$$B = B_0 \sin(Kx - \omega t)$$

DENSITY OF MAGNETIC FIELD

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

$$B = B_0 \sin(Kx - \omega t)$$

$$\mu_B = \frac{1}{2}\frac{B_0^2}{\mu_0}\sin^2(Kx - \omega t)$$

$$\overline{\mu_B} = \frac{1}{2}\frac{B_0^2}{\mu_0}\overline{\sin^2(Kx - \omega t)}$$

$$\overline{\mu_B} = \frac{1}{2}\frac{B_0^2}{\mu_0} \times \frac{1}{2}$$

$$(\mu_B)_{avg} = \frac{1}{4}\frac{B_0^2}{\mu_0}$$

Question

Which of the following is true

a

$(\mu_E)_{Avg} = (\mu_B)_{Avg}$

b

$(\mu_E)_{Avg} = 2(\mu_B)_{Avg}$

c

$2(\mu_E)_{Avg} = (\mu_B)_{Avg}$

d

$(\mu_E)_{Avg} = 4(\mu_B)_{Avg}$

ON

$$(\mu_E)_{Avg} = \frac{1}{4}\epsilon_0 E_0^2$$

$$(\mu_B)_{Avg} = \frac{1}{4\mu_0} B_0^2$$

SUMMARY

$$(\mu_E)_{Avg} = \frac{1}{4}\epsilon_0 E_0^2 \qquad (\mu_B)_{Avg} = \frac{1}{4\mu_0}B_0^2$$

$$(\mu_E)_{Avg} = \frac{1}{4}\epsilon_0 (B_0 c)^2$$

$$\frac{E_0}{B_0} = c \qquad c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

$$(\mu_E)_{Avg} = \frac{1}{4}\epsilon_0 B_0{}^2 \frac{1}{\mu_0 \epsilon_0}$$

$$(\mu_E)_{Avg} = \frac{1}{4}B_0{}^2 \frac{1}{\mu_0}$$

$$(\mu_E)_{Avg} = \frac{1}{4\mu_0}B_0^2 = (\mu_B)_{Avg}$$

$$(\mu_E)_{Avg} = (\mu_B)_{Avg}$$

Answer

Which of the following is true

a $(\mu_E)_{Avg} = (\mu_B)_{Avg}$

b $(\mu_E)_{Avg} = 2(\mu_B)_{Avg}$

c $2(\mu_E)_{Avg} = (\mu_B)_{Avg}$

d $(\mu_E)_{Avg} = 4(\mu_B)_{Avg}$

electromagnetic waves

$$\mu = \mu_E + \mu_B$$

$$\mu = \mu_E + \mu_E = 2\mu_E$$

$$\Downarrow$$

$$\mu = 2\frac{1}{4}\epsilon_0 E_0^2$$

$$\Downarrow$$

$$\boxed{\mu = \frac{1}{2}\epsilon_0 E_0^2}$$

$$\mu = \mu_B + \mu_B = 2\mu_B$$

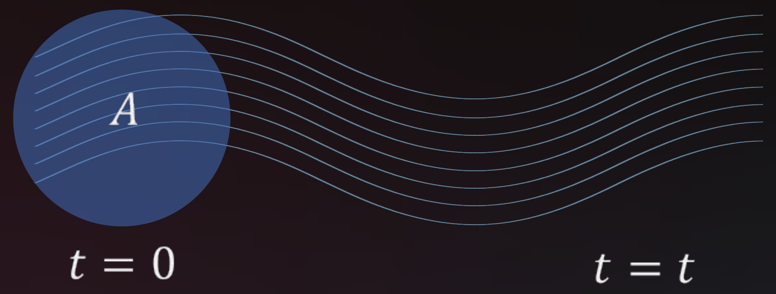
$$\Downarrow$$

$$\mu = 2\frac{1}{4\mu_0}B_0^2$$

$$\Downarrow$$

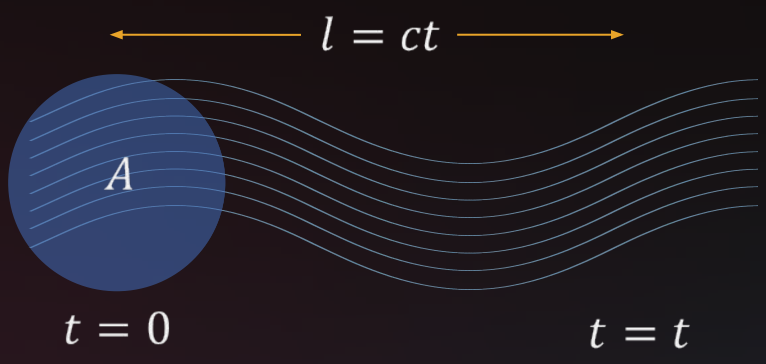
$$\boxed{\mu = \frac{1}{2\mu_0}B_0^2}$$

- The energy crossing per unit time in a direction perpendicular to the direction of propagation is called intensity of the wave (I).



- The energy crossing per unit time in a direction perpendicular to the direction of propagation is called intensity of the wave (I).

$$I = \frac{U}{At}$$



Energy (U) in unit volume of cylinder $\mu = \frac{1}{2}\epsilon_0 E_0^2$

$$U = \mu \times \text{volume}$$

$$U = \frac{1}{2}\epsilon_0 E_0^2 \times A \times ct$$

$$I = \frac{\frac{1}{2}\epsilon_0 E_0^2 \times A \times ct}{At}$$

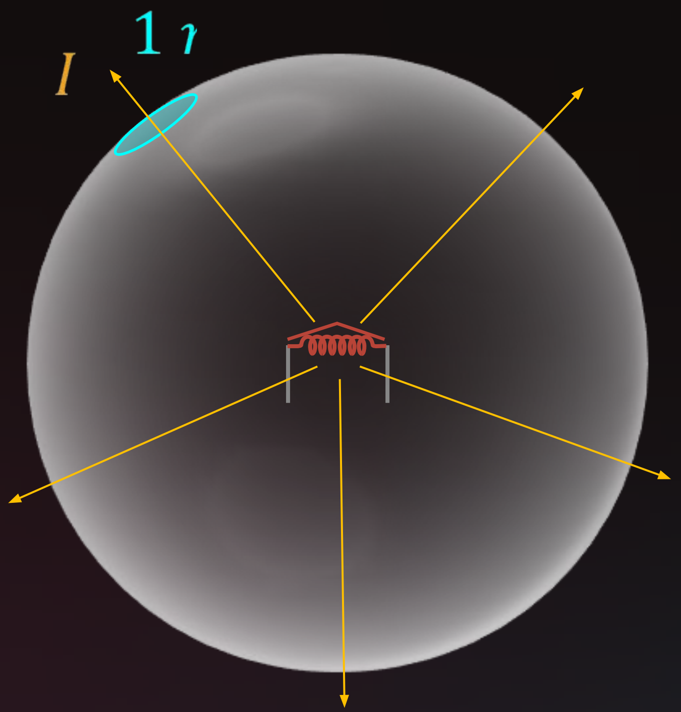
$$I = \frac{1}{2}\epsilon_0 E_0^2 c$$

Relation between power and intensity

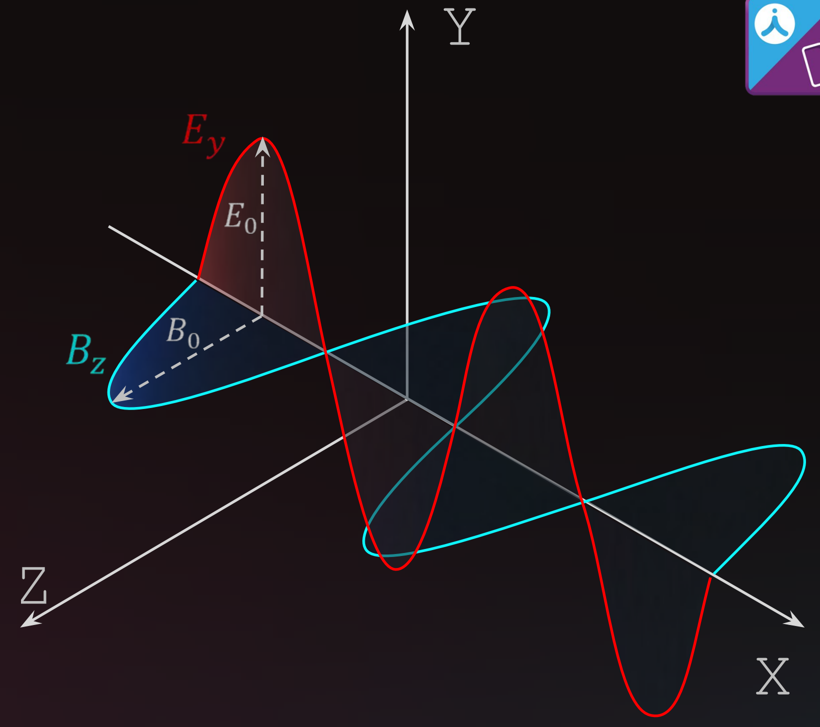
$$I = \frac{U}{At}$$

$$\frac{U}{t} = \text{Power } (P)$$

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



WAVE



WAVE

- De-Broglie hypothesis $\lambda = \frac{h}{P}$

Moment
um

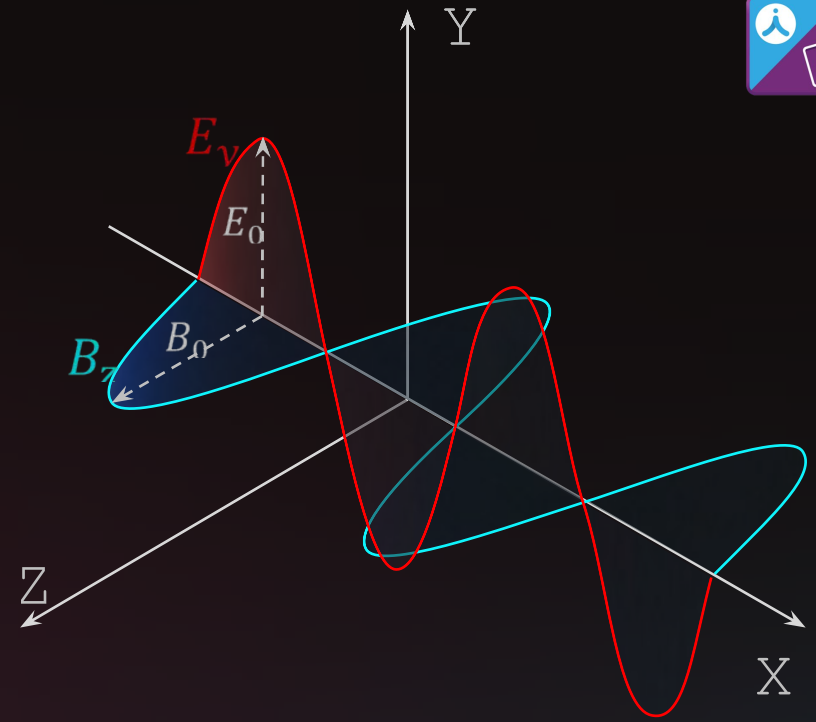
$$P = \frac{h}{\lambda}$$

$$U = hf \qquad c = f\lambda$$

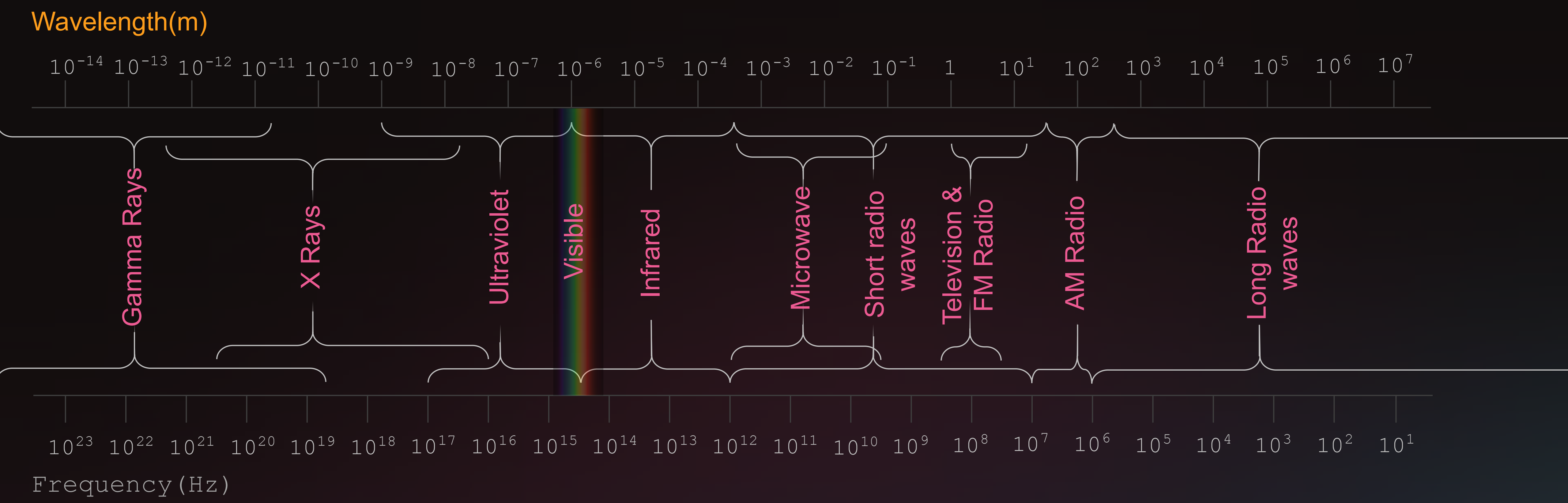
$$U = \frac{hc}{\lambda}$$

$$U = Pc$$

$$P = \frac{U}{c}$$



ELECTROMAGNETIC SPECTRUM



- The classification of EM waves according to its frequency/wavelength is called Electromagnetic Spectrum.

ELECTROMAGNETIC SPECTRUM

Frequency: $10^{19}\ Hz - 10^{24}\ Hz$

Wavelength: $< 10^{-11}\ m$

GAMMA RAYS

They are produced by the disintegration of radioactive atomic nuclei.

They are used in medicine to destroy cancer cells.

ELECTROMAGNETIC SPECTRUM

Frequency: $10^{16}\ Hz - 10^{20}\ Hz$

Wavelength: $< 10^{-8} - 10^{-12}\ m$

X-RAYS

X-rays are produced most commonly when fast moving electrons decelerates inside a metal target.

They are harmful to living tissues.

They are widely used in medical

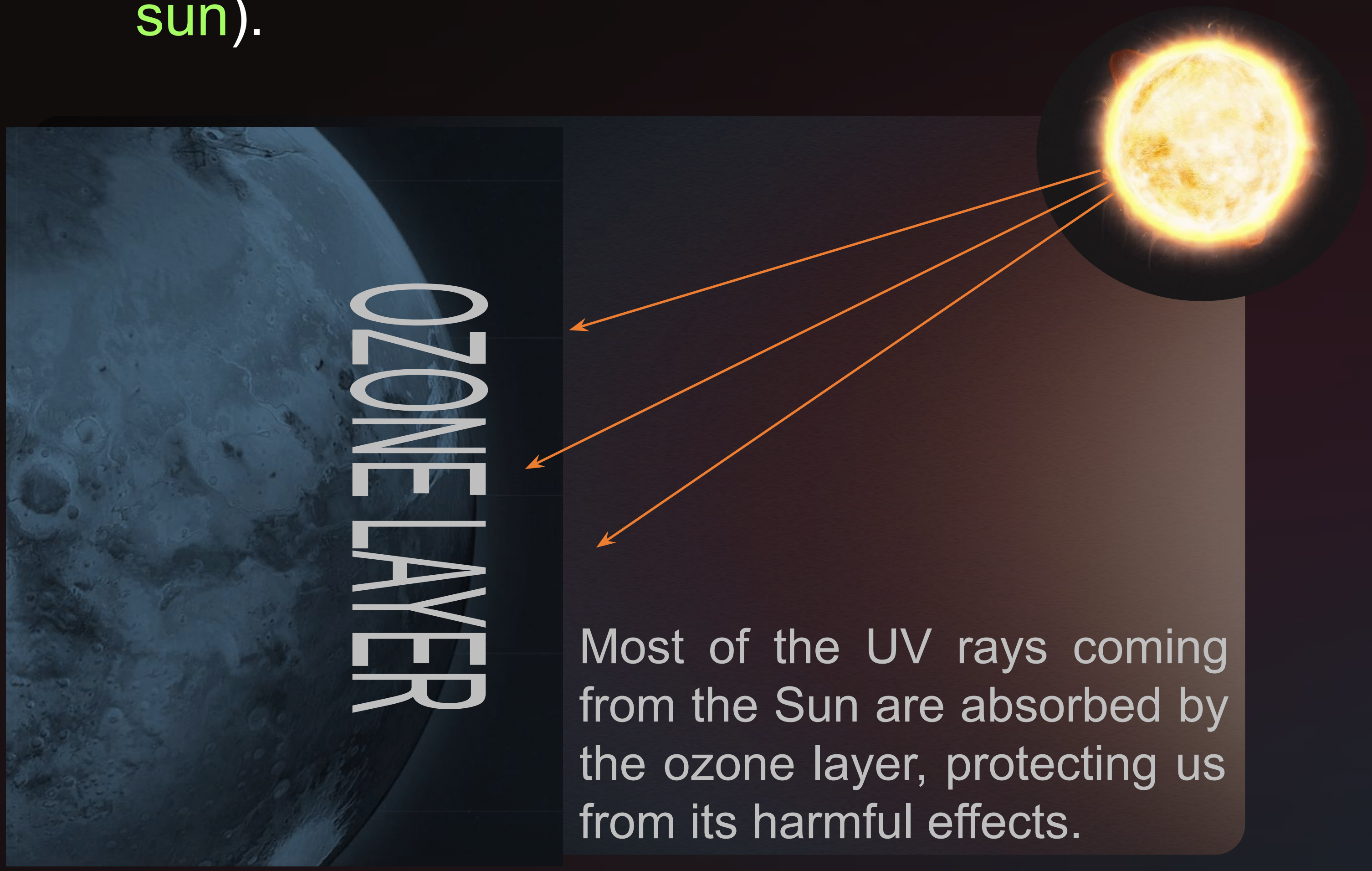
ELECTROMAGNETIC SPECTRUM

ULTRAVIOLET RAYS

Frequency: $10^{15}\ Hz - 10^{17}\ Hz$

Wavelength: $< 400nm - 1\ nm$

UV-rays are produced by special lamps and very hot bodies (eg sun).

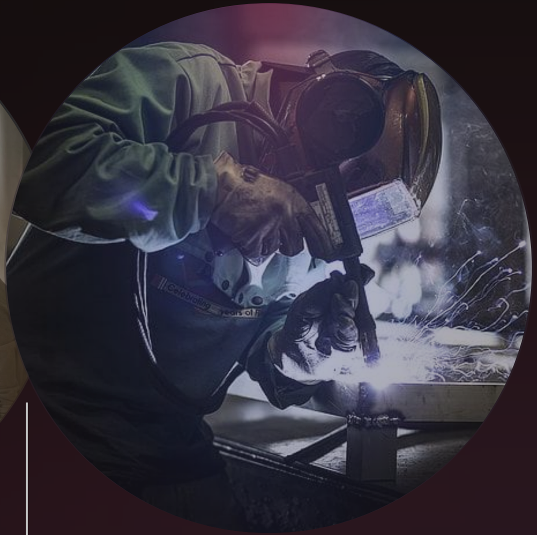


Most of the UV rays coming from the Sun are absorbed by the ozone layer, protecting us from its harmful effects.

ELECTROMAGNETIC SPECTRUM

ULTRAVIOLET RAYS

UV radiation is absorbed by ordinary glass.



Welders wear special glass shields to protect their eyes from large amount of UV produced by welding arcs.

They are used in eye surgery and for water purification.

ELECTROMAGNETIC SPECTRUM

Frequency: $4 \times 10^{14}\ Hz - 7 \times 10^{14}\ Hz$

Wavelength: $< 700nm - 400\ nm$

VISIBLE RAYS

It is the part of the spectrum that is detected by the human eye.

ELECTROMAGNETIC SPECTRUM

Frequency: $10^{12}\ Hz\ - 10^{14}\ Hz$

Wavelength: $< 780nm - 1000\ \mu m$

INFRARED RAYS

They are produced by hot bodies and molecules. They are also known as HEAT WAVES.

THERMAL IMAGING using Infrared radiation.

They are used in the remote switches of household electronic system.

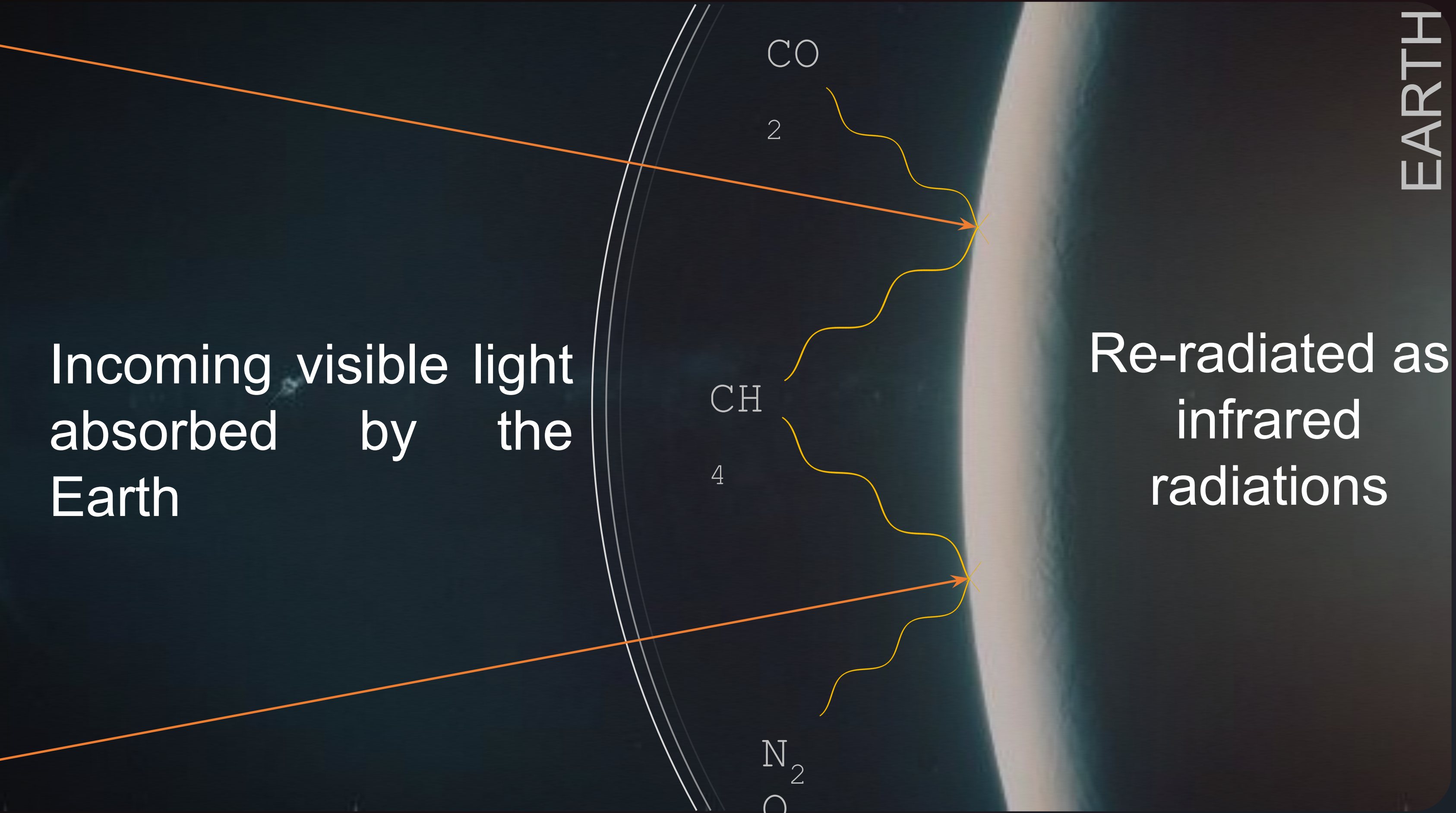
ELECTROMAGNETIC SPECTRUM

Frequency: $10^{12}\ Hz - 10^{14}\ Hz$

Wavelength: $< 780nm - 1000\ \mu m$

INFRARED RAYS

It plays an important role in maintaining the earth's warmth through the GREENHOUSE EFFECT.



ELECTROMAGNETIC SPECTRUM

Frequency: $3 \times 10^{10}\ Hz - 10^{12}\ Hz$

Wavelength: $< 1mm - 25\ mm$

Microwaves

They are produced by special vacuum tubes.

Due to their shorter wavelengths, they are suitable for the radar system used in aircraft navigation.

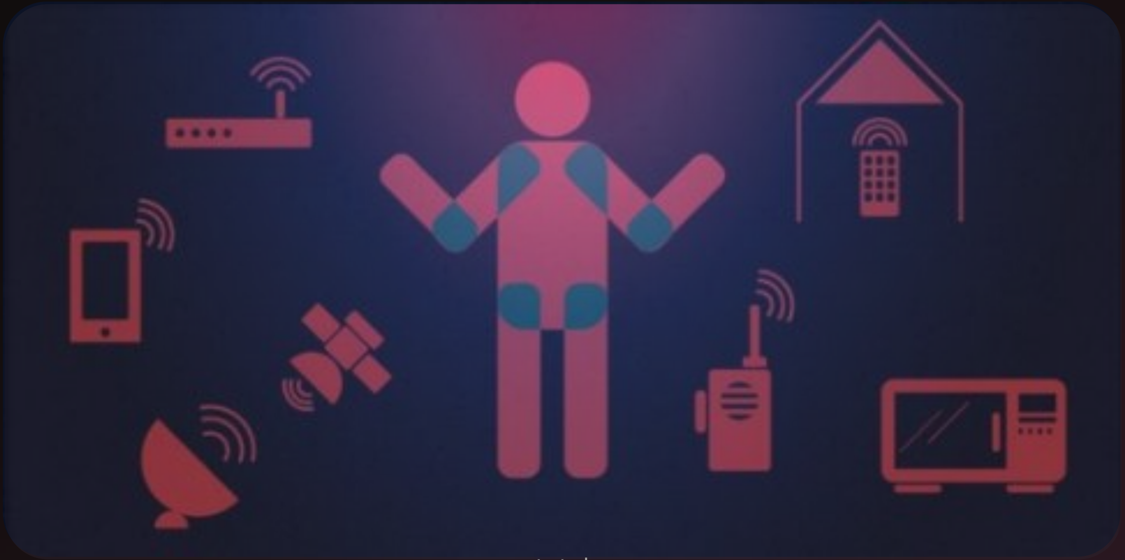
Microwave oven is an interesting domestic application of these waves.

ELECTROMAGNETIC SPECTRUM

Frequency: $< 3 \times 10^{11}\ Hz$

Wavelength: $> 1mm$

RADIO WAVE



- They produced by the accelerated motion of charges are in conducting wires
- They are used in radio and television communication system.

Amplitude Modulated (AM) radio wave (530 kHz-1710 kHz)

Television radio wave (54 MHz-890 MHz)

Frequency Modulated (FM) radio wave (88 MHz-108 MHz)

Question

The energy of the E.M.Waves is of the order of 15 keV. To which part of the spectrum does it belong?

a) Ultraviolet rays

b) $\gamma - rays$

c) $X - rays$

d) Infra-red rays

ON

Given: $E = 15\ keV$

$hc = 1240\ eV\ nm$

Y

Given: $E = 15\ keV$

$hc = 1240\ eV\ nm$

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

$$\lambda = \frac{1240}{15 \times 10^3}$$

$$\lambda = 0.083\ nm$$

This wavelength belongs to X −rays

Answer

The energy of the E.M.Waves is of the order of 15 keV.To which part of the spectrum does it belong?

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(a) Ultraviolet rays

(b) $\gamma - rays$

(c) $X \ - rays$

(d) Infra-red rays

Question

If λ_v, λ_x and λ_m represent the wavelengths of visible light , $X-rays$ and microwaves respectively, then

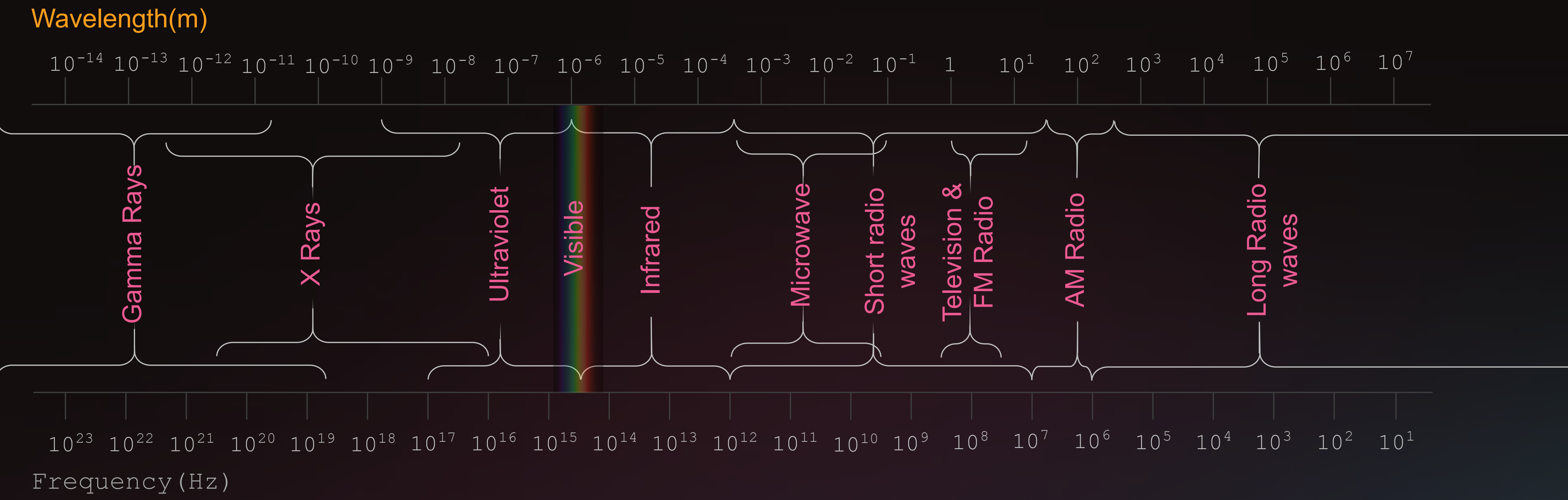
a) $\lambda_m > \lambda_x > \lambda_v$

b) $\lambda_m > \lambda_v > \lambda_x$

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

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

ON


Wavelength(m)
10-14 10-13 10-12 10-11 10-10 10-9 10-8 10-7 10-6 10-5 10-4 10-3 10-2 10-1 1 101 102 103 104 105 106 107
Gamma Rays
X Rays
Ultraviolet
Visible
Infrared
Microwave
Short radio waves
Television & FM Radio
AM Radio
Long Radio waves
1023 1022 1021 1020 1019 1018 1017 1016 1015 1014 1013 1012 1011 1010 109 108 107 106 105 104 103 102 101
Frequency (Hz)

Answer

If λ_v, λ_x and λ_m represent the wavelengths of visible light , $X - rays$ and microwaves respectively, then

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a) $\lambda_m > \lambda_x > \lambda_v$

b) $\lambda_m > \lambda_v > \lambda_x$

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

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

Question

Oxone layer blocks the radiation of wavelength

NEET 2005

a) More than $3 \times 10^{-7}\ m$

b) Equal to $3 \times 10^{-7}\ m$

c) Less than $3 \times 10^{-7}\ m$

d) All of these

Answer

Oxone layer blocks the radiation of wavelength

NEET 2005

(a) More than $3 \times 10^{-7}\ m$

(b) Equal to $3 \times 10^{-7}\ m$

(c) Less than $3 \times 10^{-7}\ m$

(d) All of these

Question

Oxone layer blocks the radiation of wavelength

NEET 1999

a. More than $3 \times 10^{-7}\ m$

b. Equal to $3 \times 10^{-7}\ m$

c. Less than $3 \times 10^{-7}\ m$

d. All of these

Answer

Oxone layer blocks the radiation of wavelength

NEET 1999

(a) More than $3 \times 10^{-7}\ m$

(b) Equal to $3 \times 10^{-7}\ m$

(c) Less than $3 \times 10^{-7}\ m$

(d) All of these