9.ELECTROMAGNETIC RADIATIONS

SOLUTIONS

Teaching Task

1. Which radiation has the longest wavelength?

A) X-rays **B) Gamma rays** **C) Radio waves** **D) Ultraviolet**

Answer:C

Solution: Wavelength order (longest to shortest):
Radio > Microwave > IR > Visible > UV > X-rays > Gamma rays

2.The frequency of green light (λ = 550 nm) is:

A) 5.45 × 10^{14} Hz **B) 3.00 × 108 Hz** **C) 1.82 × 10^{15} Hz** **D) 550 Hz**

Answer:A

Solution: $\upsilon = \frac{c}{\lambda} = \frac{3\times10^{8}}{550\times10^{-9}} = 5.45\times10^{14}\,Hz$

3.Which is not an electromagnetic wave?

A) Infrared **B) Sound waves** **C) Microwaves** **D) Visible light**

Answer:B

Solution: Sound waves (Mechanical wave, not EM wave)

4.The energy order of EM radiation is:

A) UV > IR > Microwave > Gamma **B) Gamma > UV > IR > Microwave**

C) Microwave > IR > UV > Gamma **D) IR > UV > Gamma > Microwave**

Answer:B

Solution:Gamma > UV > IR > Microwave (Energy order: Gamma (highest) ? Microwave (lowest))

5.If λ_1 (X-rays) = 0.1 nm and λ_2 (radio waves) = 100 m, the ratio λ_2/λ_1 is:

A) 10^{9} **B) 10^{-9}** **C) 10^{12}** **D) 10^{-12}**

Answer:C

Solution:

$\lambda_1 = 0.1nm = 0.1\times10^{-9}\,m = 10^{-10}\,m$

$\frac{\lambda_2}{\lambda_1} = \frac{100}{10^{-10}} = 10^{12}$

6.A helium-neon laser emits light at 632.8 nm. The wavenumber (cm^{-1}) is:

A) 1.58 × 10^{4} **B) 6.33 × 10^{-5}** **C) 1.58 × 10^{6}** **D) 6.33 × 10^{3}**

Answer:A

Solution: $\bar{\upsilon} = \frac{1}{\lambda} = \frac{1}{632.8\times10^{-7}} = 1.58\times10^{4}$

7.Which statement is false?

A) Cosmic rays have higher frequency than gamma rays.

B) Radio waves travel at the same speed as X-rays in vacuum.

C) UV rays can cause skin cancer.

D) Infrared is used in remote controls

Answer:A

Solution: Cosmic rays are not EM waves, but high-energy particles. Frequency comparison is invalid

8.The distance traveled by light (λ = 589 nm) in 1 nanosecond is:

A) 0.3 m **B) 3.0 m** **C) 30 cm** **D) 589 nm**

Answer:A

Solution:Distance = speed × time = $3\times10^{8}\times10^{-9}=0.3m$

9.Which pair has the same speed in vacuum?

A) Gamma rays & Sound waves **B) Visible light & Microwaves**

C) X-rays & Ultrasonic waves **D) IR & UV in glass**

Answer:B

Solution:Both visible light and microwaves are electromagnetic waves, and all electromagnetic waves travel at the same speed in a vacuum, which is the speed of light.

10.The wave number of radiation with frequency 1.5 × 10^{14} Hz is:

A) 500 cm^{-1} **B) 5000 m^{-1}** **C) 5 × 10^{5} m^{-1}** **D) 50 m^{-1}**

Answer:C

Solution:

$$\lambda=\frac{c}{\upsilon}=\frac{3\times10^{8}}{1.5\times10^{14}}=2\times10^{-6}m=2\times10^{-4}cm$$

$$\bar{\upsilon}=\frac{1}{\lambda}=\frac{1}{2\times10^{-4}}=0.5\times10^{4}=5\times10^{3}cm^{-1}=5\times10^{5}m^{-1}$$

11.A photon of wavelength 300 nm has energy (in eV):

A) 4.14 **B) 41.4** **C) 0.414**

Answer:A

Solution: $E=\frac{hc}{\lambda}=\frac{6.626\times10^{-34}\times3\times10^{8}}{300\times10^{-9}}=6.63\times10^{-19}J$

Use the conversion factor

$1eV=1.602\times10^{-19}$

$$E_{eV}=\frac{6.63\times10^{-19}}{1.602\times10^{-19}}=4.13eV$$

12.Which transition emits radiation with the shortest wavelength?

A) n=4 $\rightarrow$ n=2 (Hydrogen) **B) n=6 $\rightarrow$ n=2 (Helium^{+})**

C) n=3 $\rightarrow$ n=1 (Lithium^{2+}) **D) n=5 $\rightarrow$n=3 (Hydrogen)**

Answer:C

Solution:For calculating wavelength of a photon, we have the formula, $\frac{1}{\lambda} = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})$

For minimum wavelength, $(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ should be maximum.

A) n=4 $\rightarrow$ n=2

$$(\frac{1}{n_1^2} - \frac{1}{n_2^2}) = \frac{1}{2^2} - \frac{1}{4^2} = 0.1875$$

B) n=6 $\rightarrow$ n=2

$$(\frac{1}{n_1^2} - \frac{1}{n_2^2}) = \frac{1}{2^2} - \frac{1}{6^2} = 0.222$$

C) n=3 $\rightarrow$ n=1

$$(\frac{1}{n_1^2} - \frac{1}{n_2^2}) = \frac{1}{1^2} - \frac{1}{3^2} = 0.888$$

D) n=5 $\rightarrow$n=3

$$(\frac{1}{n_1^2} - \frac{1}{n_2^2}) = \frac{1}{3^2} - \frac{1}{5^2} = 0.071$$

The transition n=3 to n=1 has the highest value of $(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ that is 0.8889.

- Therefore, n = 3 to n = 1 transition will have the least wavelength.

13.If the frequency of a wave doubles, its energy becomes:

A) Half **B) Double** **C) Four times** **D) Unchanged**

Answer:B

Solution: $E = h\upsilon$

E is directly proportional to frequency

14.The incorrect statement about photons is:

A) Energy α frequency **B) Momentum α wavenumber**

C) Intensity α number of photons **D) Velocity α wavelength**

Answer:D

Solution:Photon velocity is constant c in vacuum

15.A radio station broadcasts at 100 MHz. The photon energy (in J) is:

A) 6.63 × 10^{-26} **B) 6.63 × 10^{-3}** **C) 6.63 × 10^{-19}** **D) 1.66 × 10^{-25}**

Answer:A

Solution: $E = h\upsilon = 6.63\times10^{-34}\times100\times10^{6} = 6.63\times10^{-26}$

MULTIPLE CORRECT ANSWER TYPE

16. Which of the following statements about the speed of electromagnetic waves in a vacuum are correct?

A) It depends on the frequency of the wave.
B) It is the same for all types of EM radiation (e.g., radio waves, X-rays).
C) It decreases if the wavelength increases.
D) It is independent of the medium's refractive index.
Answer:B,D

Solution:B) "It is the same for all types of EM radiation."
Reason: In vacuum, all EM waves (radio, X-rays, etc.) travel at the speed of light (c ˜ 3 × 10^8 m/s), regardless of frequency or wavelength.

D) "It is independent of the medium's refractive index."
Reason: The question specifies vacuum, where refractive index = 1 (no medium effect).

17.In a helium ion (He^+) sample, two photons (X and Y) are emitted due to electronic transitions. If photon Y has a wavelength in the visible region and photon X has higher energy than Y, photon X could belong to the:

A) Ultraviolet region
B) Infrared region
C) X-ray region
D) Gamma-ray region
Answer:A,C,D

Solution:Photon Y is in the visible region (400–700 nm).

Photon X has higher energy than Y → shorter wavelength than Y.

Possible regions for X:

A) Ultraviolet (UV): Shorter λ than visible (10–400 nm).

C) X-ray: Much shorter λ (0.01–10 nm).

D) Gamma-ray: Shortest λ (< 0.01 nm).

18.Which combinations of phenomena demonstrate the wave-particle duality of light?

A) Compton effect and refraction
B) Photoelectric effect and diffraction
C) Blackbody radiation and interference
D) Polarization and electron microscopy
Answer:B,C

Solution:B) "Photoelectric effect (particle) and diffraction (wave)."
Photoelectric effect: Shows light as particles (photons).
Diffraction: Shows light as waves.

C) "Blackbody radiation (particle) and interference (wave)."
Blackbody radiation: Explained by quantized photons (particle).
Interference: Wave phenomenon (e.g., double-slit experiment).

STATEMENT TYPE

A) Both statement I and II are correct and statement II is correct explanation of statement I.
B) Both statement I and II are correct and statement II is not correct explanation of statement I.
C) Statement I is correct and statement II is incorrect.
D) Statement I is incorrect and statement II is correct.

19. Statement I: Isotopes of an element have the same number of protons but different number of neutrons.
Statement II: Isotopes always differ in their chemical behavior due to the difference in mass.
Answer:C
Solution:Statement I is correct: Isotopes do have the same atomic number (protons) but different mass numbers (neutrons).

Statement II is incorrect: Isotopes do not differ in chemical behavior because chemistry depends on electron configuration, which is identical in isotopes. Their physical properties (e.g., density) may vary due to mass differences, but not chemical reactivity.

20. Statement I: In Rutherford's alpha-particle scattering experiment, most alpha particles passed undeflected through the gold foil.
Statement II: This proved that atoms are mostly made up of empty space, with a dense positive nucleus at the center.
Answer:A
Solution:Statement I is correct: Most alpha particles passed through undeflected, indicating minimal obstruction.
Statement II is correct and explains I: The observation led to Rutherford's nuclear model, where:
Atoms are mostly empty space (explaining undeflected particles).
A tiny, dense nucleus causes rare deflections (e.g., 1 in 8000 alpha particles bounced back).

COMPREHENSION TYPE

COMPREHENSION-I

It is defined as the distance covered in one second by the wave. It is denoted by the letter 'c'. All electromagnetic waves travel with the same velocity, i.e., $3\times10^{10}\,cm/\sec$.

$$c=\lambda\nu=3\times10^{10}\ cm/\sec$$

19.What is the speed of electromagnetic waves in a vacuum?

A) It varies depending on the wavelength.

B) It is denoted by the symbol 'c' and is approximately 3×10^8 m/s.

C) It is different for different types of EM waves (e.g., X-rays travel faster than radio waves).

D) It depends on the intensity of the radiation.

Answer:B

Solution:The speed of all electromagnetic waves in a vacuum is constant and denoted by 'c' (approximately 3×10^8 m/s).

This speed is independent of wavelength, frequency, or intensity (Options A, C, D are incorrect).

20.Which of the following statements is true about electromagnetic waves?

A) Gamma rays travel faster than visible light in a vacuum.

B) The speed of EM waves changes if the frequency increases.

C) In a vacuum, all EM waves (radio, X-rays, light) have the same speed.

D) The velocity of EM waves depends on their amplitude.

Answer:C

Solution:In a vacuum, all EM waves travel at speed 'c' (3×10^8 m/s), whether they are radio waves, X-rays, or visible light.

COMPREHENSION-II

According to Newton's corpuscular theory, light propagates as stream of particles known as corpuscles.

This particle nature of light was able to explain the phenomena like reflection and refraction.

21.According to Newton's corpuscular theory, light propagates as:

A) Transverse waves in ether **B) Vibrations of electric and magnetic fields**

C) A stream of tiny particles called corpuscles **D) Standing waves in vacuum**

Answer:C

Solution:Newton proposed that light consists of tiny particles (corpuscles) moving in straight lines

22.Newton's corpuscular theory was able to explain which of the following phenomena?

A) Interference and diffraction **B) Reflection and refraction**

C) Polarization and photoelectric effect **D) Emission spectra of hydrogen atom**

Answer:B

Solution:Reflection: Corpuscles rebound elastically off surfaces (like billiard balls).

Refraction: Newton hypothesized that corpuscles speed up when entering denser media (e.g., water), bending toward the normal. (Note: This was later proven incorrect—light slows down in denser media, but the theory could still "explain" refraction qualitatively.)

INTEGER TYPE

23.The wavelength of a radiation is 500 nm. Its wave number is x cm^{-1}. Then, the value of x is: _____

Answer:20000

Solution:

$$\bar{\upsilon} = \frac{1}{\lambda} = \frac{1}{500 \times 10^{-7} cm} = 20000 cm^{-1}$$

24.A radiation has a frequency of 6 × 10^{14} Hz. Speed of light is 3 × 10^{8} m/s. The wavelength of this radiation is x × 10^{-7} m. Find the value of x: _____

Answer:5

Solution:

$$\lambda = \frac{c}{\upsilon} = \frac{3 \times 10^{8}}{6 \times 10^{14}} = 5 \times 10^{-7} m$$

$$x = 5$$

25.If the velocity of light is 3 × 10^{8} m/s, and its frequency is 5 × 10^{14} Hz, find its wave number in cm^{-1}. Let the wave number be x × 10^{4} cm^{-1}. Then, value of x = _____

Answer:1.66

Solution:

$$\lambda = \frac{c}{\upsilon} = \frac{3 \times 10^{8}}{5 \times 10^{14}} = 6 \times 10^{-7} m$$

$$\bar{\upsilon} = \frac{1}{\lambda} = \frac{1}{6 \times 10^{-7}} = 1.66 \times 10^{6} m^{-1} = 1.66 \times 10^{4} cm^{-1}$$

26.1 angstrom (Å) = x picometers (pm). Find the value of x = _____

Answer:100

Solution:

$$1A^{0} = 10^{-10} m$$

$$1 pm = 10^{-12} m$$

$$1A^{0} = 100 pm$$

27.A radio wave travels at 3 × 10^8 m/s and has a wavelength of 1500 m. Find its frequency in kHz (rounded to nearest integer). Then, frequency x = _____

Answer:200

Solution:

$$\upsilon = \frac{c}{\lambda} = \frac{3\times10^8}{1500} = 2\times10^5\,Hz = 2\times10^2\,KHz = 200\,KHz$$

MATRIX MATCHING TYPE

28. List – I (Physical Quantity)

A) Energy of a photon

B) Wave number

C) Frequency

D) Wavelength

List – II (Related Expression or Concept)

1) Planck's constant × frequency

2) Inversely proportional to wavelength

3) Inversely proportional to time period

4) Inversely proportional to wave number

A)1 2 3 4 **B)1 3 2 4**

C)2 1 3 4 **D)1 2 4 3**

Answer:A

Solution:

A) Energy of a photon — 1) Planck's constant × frequency($E = h\upsilon$)

B) Wave number — 2) Inversely proportional to wavelength($\bar{\upsilon} = \frac{1}{\lambda}$)

C) Frequency — 3) Inversely proportional to time period($\upsilon = \frac{1}{T}$)

D) Wavelength — 4) Inversely proportional to wave number($\lambda = \frac{1}{\upsilon}$)

Learners Task

CONCEPTUAL UNDERSTANDING QUESTIONS (CUQ's)

1. All types of electromagnetic radiation in a vacuum have the same:

A) Wavelength B) Frequency C) Energy D) Velocity

Answer:D

Solution: In vacuum, all EM waves travel at the speed of light (c ˜ 3×108 m/s), regardless of their wavelength, frequency, or energy.

2.Which radiation has the highest wavenumber?

A) Microwaves B) X-rays C) Infrared radiation D) Radio waves

Answer:B

Solution:Wavenumber ($\bar{\upsilon} = \frac{1}{\lambda}$) is inversely proportional to wavelength. X-rays have the shortest wavelength among the options, hence highest wavenumber.

3.Arrange the following in increasing order of energy:

A) Radio waves, Microwaves, UV light, Gamma rays

B) Microwaves, Visible light, X-rays, Gamma rays
C) Infrared, UV, Visible, Gamma
D) Radio, IR, Visible, Microwaves
Answer:A,B
Solution:

$$E\alpha\upsilon\alpha\frac{1}{\lambda}$$

A) Radio < Microwaves < UV < Gamma rays
B) Microwaves < Visible light < X-rays < Gamma ray

4.Which pair is incorrectly matched?
A) Wavelength $\rightarrow$ Nanometers **B) Frequency $\rightarrow$ Hertz**
C) Wavenumber $\rightarrow$ **m^{-1}** **D) Velocity $\rightarrow$ ergs**
Answer:D
Solution:Velocity units: m/s (ergs are units of energy)

5.The product of which two gives the speed of light?
A) Wavelength × Wavenumber **B) Wavelength × Frequency**
C) Frequency × Wavenumber **D) Wavelength × Amplitude**
Answer:B
Solution: Fundamental relation c = $\upsilon\lambda$ (speed = wavelength × frequency)

6.If the frequency of a wave is 6×10^{14} Hz, its wavelength is:
A) 500 nm
B) 600 nm
C) 700 nm
D) 800 nm
Answer:A
Solution:

$$\lambda = \frac{c}{\upsilon} = \frac{3\times10^{8}}{6\times10^{14}} = 0.5\times10^{-6}m = 0.5\times10^{-6}\times10^{9} = 500nm$$

7.The frequency of green light (λ = 500 nm) is:
A) 6×10^{14} Hz
B) 3×10^{8} Hz
C) 1.5×10^{15} Hz
D) 5×10^{13} Hz
Answer:A
Solution:

$$\upsilon = \frac{c}{\lambda} = \frac{3\times10^{8}}{500\times10^{-9}} = 6\times10^{14}m$$

8.Which property is independent of others in a wave?
A) Wavenumber **B) Wavelength** **C) Frequency** **D) Amplitude**
Answer:D
Solution:Wavenumber (A), wavelength (B), and frequency (C) are related through

c = $\upsilon\lambda$ and $\lambda = \frac{1}{\upsilon}$

Amplitude (D) measures wave height and is independent of these.

9.The wavelength of light with wavenumber 4000 cm^{-1} is:
A) 2.5 μm **B) 250 nm** **C) 25 m** **D) 25 nm**
Answer:A

Solution: $\lambda = \frac{1}{\upsilon} = \frac{1}{4000} = 2.5\times10^{-4} cm = 2.5\mu m$

10.Which is NOT an electromagnetic wave?
A) Gamma rays **B) Alpha rays** **C) Radio waves** **D) X-rays**
Answer:B
Solution:Alpha rays are helium nuclei (particles), not EM waves.
Others (A, C, D) are EM waves.

11.Which particle has the shortest de Broglie wavelength at the same velocity?
A) Electron **B) Proton** **C) Alpha particle**
Answer:C
Solution:
λ = h/(mv) - heavier mass (alpha particle > proton > electron) gives shorter λ.

12.Which radiation is used in rotational spectroscopy?
A) X-rays **B) UV-Visible** **C) Microwaves** **D) Gamma rays**
Answer:C
Solution:Rotational energy transitions in molecules correspond to microwave frequencies.

13.A photon emitted by a hydrogen atom in the Balmer series has a wavelength of 656 nm. Its energy is:
A) 3.03 × 10^{-19} J **B) 1.65 × 10^{-18} J** **C) 4.5 × 10^{-20} J** **D) 6.62 × 10^{-34} J**
Answer:A

Solution: $E = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{656\times10^{-9}} = 0.0303\times10^{-17} = 3.03\times10^{-19} J$

JEE MAIN LEVEL QUESTIONS

1.Calculate the wavenumber (in m^{-1}) of a spectral line with a frequency of 5×10^{16} Hz.

A) $1.666 \times 10^{8}\ m^{-1}$ B) $0.666 \times 10^{8}\ m^{-1}$
C) $4.126 \times 10^{6}\ m^{-1}$ D) $3.133 \times 10^{4}\ m^{-1}$
Answer:A
Solution:

$$\lambda = \frac{c}{\upsilon} = \frac{3\times10^{8}}{5\times10^{16}} = 6\times10^{-9}m$$
$$\bar{\upsilon} = \frac{1}{\lambda} = \frac{1}{6\times10^{-9}} = 1.66\times10^{8}m^{-1}$$

2.The frequency of the yellow line in sodium's spectrum is 5.09×10^{14} Hz. Its wavelength (in nm) is:

A) 510 nm B) 420 nm C) 589 nm D) 622 nm
Answer:C

Solution: $\lambda = \frac{c}{\upsilon} = \frac{3\times10^{8}}{5.09\times10^{14}} = 0.589\times10^{-6}m = 0.589\times10^{-6}\times10^{9}nm = 589nm$

3.The frequency ratio of violet light (λ = 400 nm) to red light (λ = 750 nm) is:

A) 8/15 B) 4/15 C) 15/8 D) None of these
Answer:C
Solution:

$$\upsilon_V = \frac{c}{\lambda_V} = \frac{3\times10^{8}}{400\times10^{-9}} = 7.5\times10^{14}$$
$$\upsilon_R = \frac{c}{\lambda_R} = \frac{3\times10^{8}}{750\times10^{-9}} = 4\times10^{14}$$
$$\frac{\upsilon_V}{\upsilon_R} = \frac{7.5\times10^{14}}{4\times10^{14}} = \frac{7.5}{4} = \frac{15}{8}$$

4.The time period of a sound wave is 0.02 s. If its speed is 330 m/s, its wavelength is:

A) 0.06 m B) 6.6 m C) 0.03 m D) 0.3 m
Answer:B
Solution: $\lambda = \upsilon \times T = 330\times0.02 = 6.6m$

5.The wavelengths of two radiations are 200 nm and 300 nm. Which statement is correct?

A) The 200 nm radiation has higher energy than the 300 nm radiation.
B) Both radiations have the same energy.
C) The 300 nm radiation has higher frequency.
D) The 200 nm radiation is in the infrared region.
Answer:A

Solution:Energy (E) = hc/ λ $\rightarrow$ Shorter λ (200 nm) = Higher energy.

6.Which property of a wave is independent of the others?

A) Wave number (depends on λ) **B) Wavelength (related to υ)**
C) Frequency (related to λ) **D) Amplitude**
Answer:D

Solution:Amplitude (wave height) is independent of λ, υ, or $\bar{\upsilon}$, which are interrelated via $c = \upsilon\lambda$ and $\bar{\upsilon} = \frac{1}{\lambda}$

7.Which statements about the visible spectrum are correct?

a) It consists of white light only
b) Violet radiation has longer frequency
c) Red radiation has longer wavelength
d) Violet radiation has shorter wavelength
Options:
A) Only a is correct
B) Only a,b are correct
C) c,d are correct
D) a,b,c,d are correct
Answer:C

Solution:Visible light spans 400 nm (violet) to 700 nm (red).
Violet has shorter λ and higher υ than red.
White light is a mixture of colors (a is incorrect).

8.Which is correctly matched?

A)Visible – Frequency: 10^5–10^9 Hz
B)X-rays – Wavelength (Å) – Source: Radioactive decay
C)Gamma rays – Frequency – Source: Radioactive decay
D)Infrared (IR) – Wavelength (Å): 6×10^6–7600
Answer:C

Solution:A) Visible light frequency: ~10^{14} Hz (not 10^5–10^9Hz).
B) X-rays sourced from electron transitions, not decay.
D) IR wavelength range: ~700 nm–1 mm (not Å).

9.A photon emitted from a hydrogen atom (n=3$\rightarrow$2) has wavelength λ_1. A similar transition in He^+ (n=4$\rightarrow$2) has wavelength λ_2. The ratio λ_1/λ_2 is:

A) 5/27 B) 27/5 C) 9/4 D) 4/9

Answer:B

Solution:

$$\frac{1}{\lambda} = RZ^2[\frac{1}{n_1^2} - \frac{1}{n_2^2}]$$

Hydrogen atom (n=3$\rightarrow$2) has wavelength λ_1

$$\frac{1}{\lambda_1} = R(1)^2[\frac{1}{2^2} - \frac{1}{3^2}] = R[\frac{9-4}{36}] = \frac{5R}{36}$$

$$\lambda_1 = \frac{36}{5R}$$

He^+ (n=4$\rightarrow$2) has wavelength λ_2

$$\frac{1}{\lambda_2} = R(2)^2[\frac{1}{2^2} - \frac{1}{4^2}] = 4R[\frac{4-1}{16}] = \frac{3R}{4}$$

$$\lambda_2 = \frac{4}{3R}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{36}{5R}}{\frac{4}{3R}} = \frac{36}{5} \times \frac{3}{4} = \frac{27}{5}$$

ADVANCED LEVEL QUESTIONS

MULTIPLE CORRECT ANSWER TYPE

10. Which of the following phenomena are explained by the wave nature of light?

A) Diffraction B) Interference C) Photoelectric effect D) Compton scattering

Answer:A,B

Solution:

A) Diffraction – Bending of light around obstacles (wave property).

B) Interference – Superposition of waves leading to bright/dark fringes (wave property).

C) Photoelectric effect – Explained by particle (photon) nature of light (Einstein's explanation).

D) Compton scattering – Involves photon-electron collision, requiring particle nature

11.A monochromatic light source emits photons of frequency υ. Which statements are correct?

A) If frequency doubles, energy per photon doubles

B) If intensity doubles, number of photons doubles

C) Kinetic energy of emitted photoelectrons depends on frequency
D) Momentum of photon is wavelength-dependent
Answer:A,B,C,D
Solution:
A) If frequency doubles, energy per photon doubles – Energy of a photon is E = hf, so doubling *f* doubles E.
B) If intensity doubles, number of photons doubles – Intensity depends on photon flux (number of photons per second).
C) Kinetic energy of emitted photoelectrons depends on frequency – From KE = hf - ϕ (work function).
D) Momentum of photon is wavelength-dependent – p = h/ λ (de Broglie relation).

12. Hydrogen Atom Transitions
When an electron in a hydrogen atom jumps from (n=4) to (n=2):
A) A photon of wavelength 486 nm is emitted
B) The emitted photon has energy 2.55 eV
C) The photon can eject an electron from sodium (ϕ = 2.3 eV)
D) The photon's momentum is 1.36 × **10^{-27}kg m/s**
Answer:A,B,C,D
Solution:
B)Calculate the Energy of the Emitted Photon

The energy difference between levels in hydrogen is given by: $E = 13.6[\frac{1}{n_1^2} - \frac{1}{n_2^2}]eV$

n=4 to n=2

$$E = 13.6[\frac{1}{2^2} - \frac{1}{4^2}] = 13.6\frac{4-1}{16} = 2.55eV$$

A)Calculate the Wavelength of the Emitted Photon

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

Convert E to joules:

$$E = 2.55eV \times 1.6\times10^{-19} J/eV = 4.05\times10^{-19} J$$

$$\lambda = \frac{6.63\times10^{-34}\times3\times10^{8}}{4.08\times10^{-19}} = 4.86\times10^{-7} = 486nm$$

C)Photon energy = 2.55 eV----->Correct (Photoelectric effect possible).

Work function of sodium (ϕ) = 2.3 eV

Since E>ϕ, the photon can eject an electron

D)Momentum of a photon is given by:

$$P = \frac{E}{c} = \frac{2.55\times1.6\times10^{-19}}{3\times10^{8}} = 1.36\times10^{-27} kgm/s$$

STATEMENT TYPE

A) Both statement I and II are correct and statement II is correct explanation of statement I.

B) Both statement I and II are correct and statement II is not correct explanation of statement I.

C) Statement I is correct and statement II is incorrect.

D) Statement I is incorrect and statement II is correct.

13. Statement I: The Balmer series of hydrogen lies in the visible region.

Statement II: It corresponds to electron transitions from higher orbits to the n=2 level.

Answer:A

Solution:Statement I is correct. The Balmer series includes spectral lines in the visible spectrum (e.g., 656 nm red, 486 nm blue-green, 434 nm violet).

Statement II is correct. The Balmer series is defined by transitions ending at n=2.

Does II explain I? Yes! Transitions to n=2 release photons with energies corresponding to visible light.

14.Statement I: Sodium metal emits electrons when irradiated with blue light but not with red light.

Statement II: Blue light photons have higher energy than the work function of sodium, while red light photons do not.

Answer:A

Solution:Statement I is correct. Blue light (higher frequency, ~2.55 eV for 486 nm) can eject electrons from sodium (ϕ=2.3 eV), but red light (~1.9 eV for 650 nm) cannot.

Statement II is correct. It directly compares photon energies to the work function.

Does II explain I? Yes! The energy difference explains the observed phenomenon.

COMPREHENSION TYPE

COMPREHENSION-I

Visible region constitutes a very small portion of electromagnetic spectrum. The violet colour has the minimum wavelength (maximum frequency) and red colour has maximum wavelength (minimum frequency).

Human eye can detect only the radiations which fall in the visible region (VIBGYOR) by their characteristic colours. The electromagnetic radiation on either side of this region are identified by different names

15.Which colour in the visible spectrum has the maximum frequency and minimum wavelength?

A) Red B) Orange C) Green D) Violet

Answer:D

Solution:The violet color in the visible spectrum has the maximum frequency and minimum wavelength.

16.What is true about electromagnetic radiation outside the visible region?

A) They cannot be detected by any instrument.

B) They are part of the visible spectrum but appear black.

C) They are identified by different names such as UV, IR, etc.

D) Human eyes can detect them if their intensity is high.

Answer:C

Solution:Visible spectrum is a small part of the electromagnetic spectrum, with violet having the highest frequency and shortest wavelength.

Radiation beyond the visible range (e.g., UV, X-rays, radio waves) is not visible to humans but is identified by distinct names and detected using specialized instruments.

COMPREHENSION-II

Light and other forms of radiant energy propagate without any medium in the space in the form of waves are known as *electromagnetic radiations*. These waves can be produced by a charged body moving in a magnetic field or a magnet in a electric field. e.g. $\gamma-$rays, cosmic rays, ordinary light rays etc.The arrangement of different electromagnetic radiations in the order of increasing wavelength or frequency is known as electromagnetic spectrum.

17.Which of the following statements is correct?

A) Lamps with mercury vapors produce IR rays

B) Radio waves are produced from alternating current of low frequency

C) X-rays are produced by striking a metal plate with alpha rays

D) All are incorrect

Answer:B

Solution:Radio waves come from oscillating/alternating currents at low frequencies. Mercury-vapour lamps emit visible/UV (not primarily IR), and X-rays come from high-energy electrons hitting a metal target (not alpha rays).

18.If the wavelength of X-rays is λ, then the wavelength of infrared rays is equal to:

A) $\lambda/1000$

B) 1000λ

C) λ^2

D) $\sqrt{\lambda}$

Answer:B

Solution: Infrared wavelengths are much longer than X-rays, so the IR wavelength will be many times λ; of the choices given, 1000λ (a longer wavelength) is the correct qualitative choice

INTEGER TYPE

19.If a gamma ray emitted from a radioactive substance has a frequency of 10^{20} Hz and a visible light wave (yellow) has a frequency of 5×10^{14} Hz, then how many times is the frequency of the gamma ray greater than that of the visible light?

Answer:200000

Solution:

$$Ratio = \frac{\upsilon_{gamma}}{\upsilon_{visible}} = \frac{10^{20}}{5\times10^{14}} = \frac{1}{5}\times10^{6} = \frac{10}{5}\times10^{5}$$

$$\frac{\upsilon_{gamma}}{\upsilon_{visible}} = 2\times10^{5} = 200000$$

The gamma ray's frequency is 200,000 times greater than that of the visible yellow light.

MATRIX MATCHING TYPE

20. List - I (Electromagnetic Radiation)	**List - II (Typical Wavelength Range)**
I) Gamma rays	a) 400 - 700 nm
II) X-rays	b) 1 mm - 1 m
III) Visible light	c) < 0.01 nm
IV) Microwaves	d) 0.01 nm - 10 nm

Answer:I-c,II-d,III-a,IV-b

Solution:

I) Gamma rays	c) < 0.01 nm
II) X-rays	d) 0.01 nm - 10 nm
III) Visible light	a) 400 - 700 n
IV) Microwaves	b) 1 mm - 1 m

KEY

				Teaching Task					
1	2	3	4	5	6	7	8	9	10
C	A	B	B	C	A	A	A	B	C
11	12	13	14	15	16	17	18	19	20
A	C	B	D	A	B,D	A,C,D	B,C	C	A
19	20	21	22	23	24	25	26	27	28
B	C	C	B	20000	5	1.66	100	200	A
				Learners Task					
				CUQ'S					
1	2	3	4	5	6	7	8	9	10
D	B	A,B	D	B	A	A	D	A	B
11	12	13							
C	C	A							
			JEE MAIN LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	
A	C	C	B	A	D	C	C	B	
			ADVANCED LEVEL QUESTIONS						
10	11	12	13	14	15	16	17	18	19
A,B	A,B,C,D	A,B,C,D	A	A	D	C	B	B	200000
20									
I-c,II-d,III-a,IV-b									