Electromagnetic Waves and the Spectrum

Use this key to check answers and read the explanations.

1. Which named region of the electromagnetic spectrum contains the wavelengths human eyes can see?
   - A. Visible light
   - B. Infrared
   - C. Radio waves
   - D. X-rays

   Correct answer: A. Visible light
   Visible light is the band that human eyes detect. Other regions can be detected using instruments.

2. Which band has longer wavelengths than infrared, visible light, and ultraviolet?
   - A. X-rays
   - B. Gamma rays
   - C. Radio waves
   - D. Ultraviolet

   Correct answer: C. Radio waves
   Radio waves lie toward the long-wavelength, low-frequency end of the electromagnetic spectrum.

3. Which band lies between visible light and X-rays in the usual order of increasing frequency?
   - A. Infrared
   - B. Ultraviolet
   - C. Radio
   - D. Microwave

   Correct answer: B. Ultraviolet
   Ultraviolet lies just beyond the violet end of visible light and has a lower frequency than the X-ray band in this ordering.

4. In the usual visible spectrum, which of these colors corresponds to the longest wavelengths?
   - A. Green
   - B. Violet
   - C. Blue
   - D. Red

   Correct answer: D. Red
   Red appears at the long-wavelength end of visible light. Violet is at the short-wavelength end.

5. A thermal camera maps temperature differences by detecting radiation beyond the red end of visible light. Which band is it designed to detect?

A. Ultraviolet
B. Infrared
C. Gamma rays
D. Visible violet

Correct answer: B. Infrared
Thermal cameras detect infrared radiation emitted by surfaces and use it to help estimate their temperatures.

6. A pulse of infrared and a pulse of ultraviolet leave the same point in a vacuum at the same instant. Which arrives first at a detector a fixed distance away?

A. They arrive together
B. The infrared pulse
C. The ultraviolet pulse
D. Both stop without air

Correct answer: A. They arrive together
In a vacuum all electromagnetic waves propagate at the same speed, about 3.00×10^8 m/s.

7. Two electromagnetic waves are in a vacuum. Wave A has half the wavelength of Wave B. How do their frequencies compare?

A. Wave A has four times the frequency
B. Wave A has half the frequency
C. They have equal frequencies
D. Wave A has twice the frequency

Correct answer: D. Wave A has twice the frequency
The product of wavelength and frequency is fixed at the speed of light in vacuum. Halving wavelength doubles frequency.

8. A beam has a wavelength of about 550 nm in vacuum. Which region is it in?

A. Radio waves
B. Gamma rays
C. Visible light
D. Microwaves

Correct answer: C. Visible light
A wavelength of 550 nanometers falls in the visible range, near green.

9. A telescope records a long-wavelength radio signal from a galaxy but no detectable visible light from it. What can be concluded from the radio detection alone?

A. The galaxy emits electromagnetic radiation our eyes cannot see
B. The telescope detected a sound wave traveling through space
C. The radio signal must have a higher frequency than visible light
D. The radio detection proves visible light travels faster

Correct answer: A. The galaxy emits electromagnetic radiation our eyes cannot see
Radio and visible light are both electromagnetic radiation. Radio waves have wavelengths beyond what human eyes can detect.

10. Which has more energy per photon, ultraviolet light or infrared light?

A. Energy depends only on the beam’s total brightness
B. Infrared light
C. They always have equal photon energy
D. Ultraviolet light

Correct answer: D. Ultraviolet light
Each photon’s energy is proportional to its frequency. Ultraviolet light has a higher frequency than infrared.

11. A radio wave has frequency 100 MHz. Using 3.00×10^{8} m/s for light speed in vacuum, what is its wavelength?

A. 300 m
B. 0.333 m
C. 3.00 m
D. 0.0300 m

Correct answer: C. 3.00 m
Convert 100 MHz to 1.00×10^{8} Hz. Divide speed by frequency to get 3.00 meters.

12. A beam has a wavelength of 600 nm in vacuum. Using 3.00×10^{8} m/s, what is its frequency?

A. 2.00×10^{14} Hz
B. 5.00×10^{14} Hz
C. 5.00×10^{6} Hz
D. 1.80×10^{11} Hz

Correct answer: B. 5.00×10^{14} Hz
Convert 600 nm to 6.00×10^{-7} m. Dividing 3.00×10^{8} m/s by that wavelength gives 5.00×10^{14} Hz.

13. A photon’s wavelength in vacuum is one-quarter that of another photon. What is the ratio of their energies, shorter-wave photon to longer-wave photon?

A. 16 to 1
B. 1 to 4
C. 1 to 1
D. 4 to 1

Correct answer: D. 4 to 1
Photon energy is hc divided by the vacuum wavelength. A wavelength one-quarter as large corresponds to four times the energy.

14. Two steady beams have equal total power. Photons in beam A carry three times as much energy per photon as those in beam B. How many photons per second does A deliver compared with B?

A. One-third as many
B. Three times as many
C. The same number
D. Nine times as many

Correct answer: A. One-third as many
Power equals energy per photon times photons per second. Beam A needs one-third the photon rate to deliver the same power.

15. A detector compares infrared, visible, ultraviolet, and X-ray photons. Which ordering goes from the lowest to the highest energy per photon?

A. X-ray, ultraviolet, visible, infrared
B. Infrared, ultraviolet, visible, X-ray
C. Infrared, visible, ultraviolet, X-ray
D. Visible, infrared, ultraviolet, X-ray

Correct answer: C. Infrared, visible, ultraviolet, X-ray
Photon energy rises with frequency. These four bands increase in frequency from infrared through visible and ultraviolet to X-rays.