

Waves Carry Energy

Use wavelength and energy data to explain the electromagnetic spectrum.

S8P4.b "Construct an explanation using data to illustrate the relationship between the electromagnetic spectrum and energy."

NAME _____ DATE _____

1 READ AND MARK _____ Read it twice

YOUR JOB Underline the three sentences that compare wavelengths and photon energies. In each underlined sentence, circle the wavelength and energy values or comparison words that support the claim.

A Photon Energy Pattern

① Electromagnetic waves include radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. All travel through empty space at the same speed, but they differ in wavelength, the distance from one wave crest to the next. A photon is a packet of electromagnetic energy. Wavelength and photon energy have an inverse relationship: as wavelength decreases, energy per photon increases.

PHOTON ENERGY DATA		
Spectrum region	Wavelength (nm)	Energy per photon (J)
Microwave	1,000,000	2.0×10^{-22}
Infrared	1,000	2.0×10^{-19}
Visible light	500	4.0×10^{-19}
Ultraviolet	250	8.0×10^{-19}
X-ray	0.1	2.0×10^{-15}

② The table shows data for selected regions of the spectrum. A microwave photon with a wavelength of 1,000,000 nanometers has far less energy than a visible-light photon at 500 nanometers. Halving the visible wavelength to 250 nanometers, in the ultraviolet region, doubles the energy. The much shorter X-ray wavelength corresponds to a much larger energy value.

③ Energy carried by electromagnetic radiation can affect matter differently. Low-energy photons may cause warming when absorbed, such as infrared radiation warming an object. Higher-energy ultraviolet photons can trigger chemical changes in skin cells. Still higher-energy X-rays can pass through soft tissue and may ionize atoms. These effects do not mean one region is always useful or harmful. Exposure also matters.

2 ANSWER WITH EVIDENCE _____ Use the passage

1 Use the table to compare a microwave photon with a visible-light photon. What happens to wavelength and energy from microwave to visible light?

2 What table evidence supports the claim that ultraviolet photons have more energy than visible-light photons?

3 Explain why ultraviolet radiation is associated with chemical changes in skin cells. Use data from the table and information from paragraph 3.

4 Use the X-ray and microwave data to explain why X-rays may ionize atoms while microwaves have much less ability to cause that change.

3 YOUR TURN _____ Your own words

Choose two different spectrum regions from the table and write a three-sentence explanation of their wavelength-energy relationship. In your explanation, use both sets of data and connect the higher-energy region to one possible effect from paragraph 3.

PART 1 • READ AND MARK

Underline the three sentences that compare wavelengths and photon energies. In each underlined sentence, circle the wavelength and energy values or comparison words that support the claim. Accept any marking that follows this job and points at the right text.

PART 2 • ANSWERS

#	QUESTION	ANSWER
1	Use the table to compare a microwave photon with a visible-light photon. What happens to wavelength and energy from microwave to visible light?	The wavelength decreases from 1,000,000 nm to 500 nm, while energy increases from 2.0×10^{-22} J to 4.0×10^{-19} J.
2	What table evidence supports the claim that ultraviolet photons have more energy than visible-light photons?	Ultraviolet has a shorter wavelength, 250 nm, and greater energy, 8.0×10^{-19} J. Visible light is 500 nm and has 4.0×10^{-19} J per photon.
3	Explain why ultraviolet radiation is associated with chemical changes in skin cells. Use data from the table and information from paragraph 3.	Ultraviolet photons have more energy than visible-light photons because their wavelength is shorter, 250 nm compared with 500 nm. The passage states that higher-energy ultraviolet photons can trigger chemical changes in skin cells.
4	Use the X-ray and microwave data to explain why X-rays may ionize atoms while microwaves have much less ability to cause that change.	X-rays have a much shorter wavelength, 0.1 nm, and much greater energy, 2.0×10^{-15} J per photon. Microwaves have a wavelength of 1,000,000 nm and only 2.0×10^{-22} J per photon. The passage says higher-energy X-rays may ionize atoms.

PART 3 • YOUR TURN (SAMPLE ANSWER)

An X-ray photon has a shorter wavelength and more energy than an infrared photon. The table lists X-rays at 0.1 nm and 2.0×10^{-15} J, while infrared is 1,000 nm and 2.0×10^{-19} J. This greater photon energy helps explain why X-rays may ionize atoms.

Accept equivalent explanations that accurately state the inverse relationship and cite appropriate table values. Energy values may be written in equivalent scientific notation with correct exponents.