The Fading Chair

Use evidence to explain how absorbed radiation affects matter.

HS-PS4-4 "Engage in an evidence-based argument for the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (SEP: 7; DCI: PS4.B; CCC: Cause/Effect)"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline evidence about warming and fading, circle each radiation type named in the passage, and number two observations that support a claim about UV light.

What Happened on the Rooftop?

1. On a sunny rooftop, a red plastic chair feels hot and slowly loses color. Sunlight carries electromagnetic radiation at many frequencies, including infrared, visible light, and ultraviolet (UV). A photon at a higher frequency carries more energy than a photon at a lower frequency. When the chair absorbs a photon, its material gains that energy. Absorbed infrared and visible light can increase the motion of particles and warm the chair. Absorbed UV photons have enough energy to change some chemical bonds in its dye. Reflected light can also transfer momentum, but the heating and fading discussed here depend on absorption.

2. A class tests two pieces cut from the same red plastic chair cover. They place one behind a clear UV-blocking sheet and leave the other uncovered for several sunny weeks. The sheet passes most visible light, so both pieces look brightly lit. The uncovered piece fades more. The students also take daily temperature readings and find that the two pieces reach similar temperatures. These observations support the claim that UV absorption contributes to fading, while warmth alone does not explain the difference. They do not prove UV is the only cause of fading, since other conditions could differ.

3. Absorption depends on both the radiation and the material. A UV-blocking sheet may absorb or reflect much of the incoming UV while allowing most visible light through. The plastic beneath it then receives fewer UV photons, even though it still receives visible light. Visible light can also fade some dyes over time. A more powerful beam does not necessarily send more photons during an exposure if its frequency or exposure time changes. At a fixed frequency and exposure time, however, greater power means more photons arrive. Evidence about frequency must therefore be considered alongside how much radiation a material absorbs.

2 ANSWER WITH EVIDENCE

Use the passage

1. Why can absorbed UV contribute to fading while absorbed infrared contributes to warming? Use evidence about photon frequency and the dye.

2. Both test pieces looked brightly lit. How does that observation, together with the difference in fading, support a claim about UV?

3. A student says, "The pieces reached similar temperatures, so radiation cannot explain why one faded more." Use the test results to challenge this claim.

4. Someone claims a more powerful beam always sends more photons to a surface. Is that claim supported? Explain which conditions matter.

3 YOUR TURN

Your own words

A museum plans to display a dyed banner near a bright window. Write a four- or five-sentence argument for or against using a clear cover that blocks UV but passes most visible light. Use the rooftop test and photon energy as evidence, and explain one reason the cover cannot guarantee that the banner will never fade.

ANSWER KEY

The Fading Chair

HIGH SCHOOL · HS-PS4-4

PART 1 · READ AND MARK

Underline evidence about warming and fading, circle each radiation type named in the passage, and number two observations that support a claim about UV light. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Why can absorbed UV contribute to fading while absorbed infrared contributes to warming? Use evidence about photon frequency and the dye.	**UV photons have a higher frequency and more energy than infrared photons, and absorbed UV can change bonds in the dye. Absorbed infrared can increase particle motion and warm the plastic.**
2	Both test pieces looked brightly lit. How does that observation, together with the difference in fading, support a claim about UV?	**The sheet passed most visible light, so both pieces received visible light, but the sheet reduced UV reaching one piece. The uncovered piece faded more, supporting the claim that UV absorption contributed to fading.**
3	A student says, "The pieces reached similar temperatures, so radiation cannot explain why one faded more." Use the test results to challenge this claim.	**Similar temperatures show that warmth alone does not explain the different amounts of fading. The uncovered piece received more UV and faded more, which supports a different effect of absorbed UV.**
4	Someone claims a more powerful beam always sends more photons to a surface. Is that claim supported? Explain which conditions matter.	**No. Photon count also depends on frequency and exposure time. At a fixed frequency and exposure time, greater power means more photons arrive.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The museum should use the clear cover to reduce fading while keeping the banner visible. In the rooftop test, the piece behind a UV-blocking sheet faded less than the uncovered piece, even though both looked brightly lit. Higher-frequency UV photons carry enough energy to change some bonds in dye when absorbed, so reducing the UV that reaches the banner may protect its color. The cover cannot guarantee that the banner will never fade because visible light can also fade some dyes over time.

Accept arguments that connect a difference in absorbed radiation to an observed effect and cite specific passage evidence. Students should treat the test as support for UV's contribution, not proof that UV is the only cause of fading.