MODERN PHYSICS DAY 3: PHOTON ENERGY AND MOMENTUM

CED 15.5/15.6 · Skill 2.B · FRQ: Multiple Representations

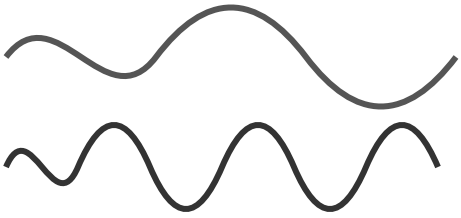
PREDICT

Compare one red photon with one blue photon. Which carries more energy and which carries more momentum?

A. red has more of both **B. blue has more of both** **C. blue has more E but less p** **D. they are equal**

Compare one photon with one photon; intensity is not part of the question.

TWO PHOTON WAVELENGTHS



red: longer λ

E? p?

blue: shorter λ

Use the wavelength difference to make one claim before calculating.

NOTES / REASONING

PHOTON ENERGY

$$E_\gamma = hf = \frac{hc}{\lambda} \qquad hc = 1240\,\text{eV}\cdot\text{nm}$$

WE DO Find the energy of a $500\,\text{nm}$ photon in electron-volts and joules. Use $1\,\text{eV} = 1.60 \times 10^{-19}\,\text{J}$.

CHECK Explain why hc/λ predicts more energy at shorter wavelength.

PHOTON MOMENTUM

$$p_\gamma = \frac{h}{\lambda} = \frac{E_\gamma}{c}$$

The relation $p = mv$ is not the momentum relation for light. A photon has zero rest mass and still carries energy and momentum.

For the $500\,\text{nm}$ photon, calculate momentum using $h = 6.63 \times 10^{-34}\,\text{J}\cdot\text{s}$. Carry the wavelength conversion and units.

Sketch the momentum-transfer arrow when this photon is absorbed by a small target.

TRANSLATE BETWEEN REPRESENTATIONS

λ	E_γ (eV)	E_γ (J)	p_γ (kg·m/s)
400 nm			
500 nm			
650 nm			

1. Complete the table to three significant figures.

2. A mirror reverses a photon's normal momentum. Compare the ideal impulse magnitude with the impulse when the photon is absorbed.

3. State what changes if the number of identical photons doubles while wavelength stays fixed.