MODERN PHYSICS DAY 4: COMPTON SCATTERING

CED 15.6 · Skill 2.C · FRQ: Qualitative/Quantitative Translation

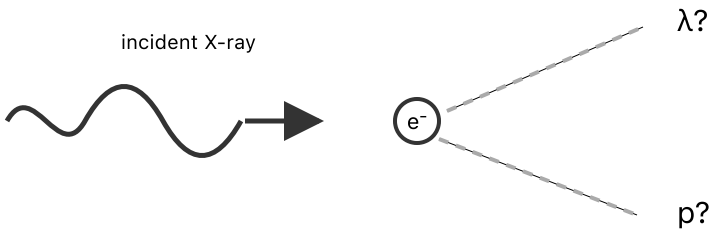
PREDICT

An X-ray photon scatters from a nearly free electron that was initially at rest. The electron recoils. Compared with the incident photon, the scattered photon wavelength is:

A. longer **B. shorter** **C. unchanged** **D. zero**

Commit before the outgoing paths are revealed.

BEFORE THE COLLISION OUTCOME IS SHOWN



Explain what your choice implies about the scattered photon's energy.

NOTES / REASONING

ENERGY AND MOMENTUM ACCOUNTS

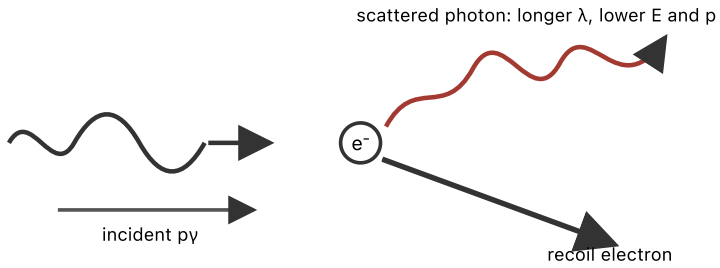
Energy: the electron's recoil kinetic energy comes from the photon.

$$E_{\gamma,i} = E_{\gamma,f} + KE_e$$

Momentum: momentum is a vector, so the outgoing photon and electron momenta add to the incident photon momentum.

$$\vec{p}_{\gamma,i} = \vec{p}_{\gamma,f} + \vec{p}_e$$

USE ARROW DIRECTION AND WAVE SPACING



Annotate the diagram with "higher/lower" for each photon's energy and momentum magnitude.

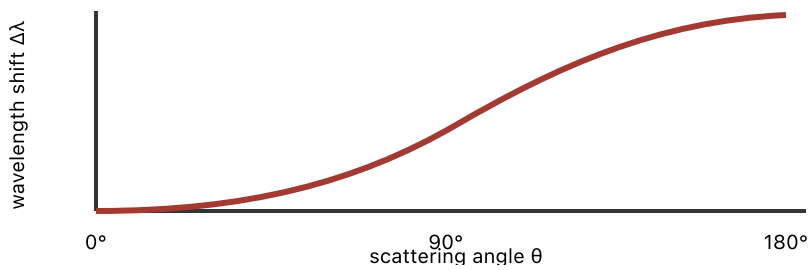
CALCULATE THE ENERGY TRANSFER

WE DO An incident X-ray photon has $\lambda_i = 0.0500\,\text{nm}$. After scattering, $\lambda_f = 0.0520\,\text{nm}$. Find the incident energy, scattered energy, and energy transferred to the electron. Use $hc = 1240\,\text{eV}\cdot\text{nm}$.

Explain why the photon still travels at c even though its energy and momentum magnitude decrease.

ANGLE AND WAVELENGTH SHIFT

MEASURED COMPTON TREND



1. At which angle is the shift smallest? At which is it largest?

2. A second event has the same incident wavelength but a larger scattering angle. Predict the scattered wavelength and electron energy transfer relative to the first event.

3. A student says the photon merely reflected from a fixed wall. Identify two features of the representation that contradict that model.

4. State the evidence that supports a particle description of light.