The Compton Effect and Photon Momentum

Multiple Choice

1. Which characterizes a photon of light?
   a. both energy and momentum
   b. energy, but not momentum
   c. momentum, but not energy
   d. neither energy nor momentum

2. If a photon has a $6.6 \times 10^{-32}$ m wavelength, what is its momentum?
   a. $4.4 \times 10^{-65}$ kg.m/s
   b. $1.0 \times 10^{-2}$ kg.m/s
   c. $1.0 \times 10^{-1}$ kg.m/s
   d. $2.4 \times 10^{-22}$ kg.m/s

3. Which property does the Compton Effect describe about photons?
   a. mass
   b. momentum
   c. wave properties
   d. speed rates

4. What did Compton discover after bombarding electrons with high energy photons?
   a. A photon’s momentum depends on its wavelength.
   b. A photon with a short wavelength can be ejected.
   c. Electrons and positrons come in pairs.
   d. Electrons can be split into smaller particles.

5. What is the momentum of a photon of yellow light with a wavelength of $5.89 \times 10^{-7}$ m?
   a. $3.90 \times 10^{-40}$ kgm/s
   b. $3.90 \times 10^{-37}$ kgm/s
   c. $1.12 \times 10^{-27}$ kgm/s
   d. $1.12 \times 10^{-25}$ kgm/s

6. If a photon of light has a wavelength of 750 nm, what is its momentum?
   a. $8.8 \times 10^{-31}$ kgm/s
   b. $8.8 \times 10^{-28}$ kgm/s
   c. $6.8 \times 10^{-30}$ kgm/s
   d. $1.1 \times 10^{-27}$ kgm/s

7. What is the wavelength of a photon which has momentum of $5.60 \times 10^{-27}$ kgm/s?
   a. $1.98 \times 10^{-12}$ m
   b. $3.64 \times 10^{-9}$ m
   c. $1.18 \times 10^{-7}$ m
   d. $8.45 \times 10^{6}$ m

8. What happens to a high energy photon after it strikes an electron?
   a. decreases frequency
   b. decreases wavelength
   c. increases energy
   d. increases momentum

9. What is the frequency of photons that have a momentum of $2.80 \times 10^{-27}$ kgm/s?
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Answer Section

MULTIPLE CHOICE

1. ANS: A  DIF: i  KEY: photon of light
2. ANS: B  DIF: ii  TOP: Momentum of photons
3. ANS: B  DIF: i  TOP: Momentum of photons
   KEY: Compton effect
4. ANS: A  DIF: i  TOP: Photon momentum
5. ANS: C  DIF: ii  TOP: Momentum of Photons
6. ANS: B  DIF: ii  TOP: photon momentum
7. ANS: C  DIF: ii  TOP: Momentum of photons
8. ANS: A  DIF: ii  TOP: photon momentum

PROBLEM

9. ANS:

Solution:

\[ p = \frac{\hbar}{\lambda} \quad \text{and} \quad \lambda = \frac{c}{f} \]

Thus,

\[ p = \frac{\hbar f}{c} \quad (1) \]

and,

\[ f = \frac{p c}{\hbar} \quad (1) \]

\[ f = \frac{(2.80 \times 10^{-21} \text{ kg m/s})(3.00 \times 10^{4} \text{ m/s})}{6.626 \times 10^{-34} \text{ J s}} = 1.27 \times 10^{15} \text{ Hz} \quad (1) \]

DIF: ii  TOP: Momentum of photons