Quiz: Compton Effect **Name:** KEY

1. The magnitude of the momentum of an X-ray photon with a frequency of 6.56×10^{19} Hz is

   a. 1.01×10^{-43} kg·m/s
   (b.) 1.45×10^{-22} kg·m/s
   c. 2.21×10^{-22} kg·m/s
   d. 3.03×10^{-43} kg·m/s

$p = \frac{h}{\lambda}$ $v = \lambda f$

Use the following information to answer the next question.

An X-ray with a wavelength of 4.60×10^{-11} m is incident upon a target. A scattered X-ray with a wavelength of 4.80×10^{-11} m is observed. The scattered angle between the initial X-ray and the scattered X-ray is ___i___ degrees, and the loss of energy by the X-ray is ___ii___ J.

2. The statement above is completed by the information in row

Row	i	ii
(a.)	79.9°	1.80×10^{-16} J
~~b.~~	34.5°	1.80×10^{-16} J
c.	79.9°	9.95×10^{-14} J
~~d.~~	34.5°	9.95×10^{-14} J

$\Delta\lambda = \frac{h}{mc}(1 - \cos\theta)$

$\theta = 79.888...°$

$\Delta E = E_f - E_i$

$\Delta E = \frac{hc}{\lambda_f} - \frac{hc}{\lambda_i}$

$\Delta E = 1.8 \times 10^{-16}$ J

3. Which of the following statements does **not** describe Compton's conclusions based on his scattering data?

   a. The scattered X-rays's momentum and energy both changed as predicted, just like if a small particle had collided elastically with an electron.

   (b.) The vector sum of the momenta of the scattered electron and the scattered X-ray could not be determined.

   c. The longer wavelength of the scattered X-ray indicated that the X-ray had lost energy in the collision.

   d. The momentum of the scattered X-ray was less than the momentum of the incident X-ray.

Numerical Response #1

In a Compton scattering experiment, an incident X-ray is scattered at an angle of 70°. Expressed in scientific notation, the change in wavelength is **a**.**b**x10^{-cd} m. The values for **a**, **b**, **c**, and **d** are _1_, _6_, _1_, and _2_.

(Record your **four** digit answer in the numerical response section.)

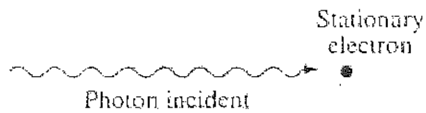
$$\Delta\lambda = \frac{h}{mc}(1-\cos\theta)$$

$$\Delta\lambda = 1.596\ldots \times 10^{-12}\ m$$

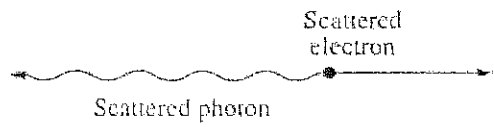
$$\Delta\lambda = 1.6 \times 10^{-12}$$

Use the following information to answer the next question.

An X-ray photon that has a wavelength of 2.000×10^{-10} m collides with a stationary electron.



The scattered X-ray photon, which has a wavelength of 2.049×10^{-10} m, returns along the initial path.



4. Calculate the velocity of the scattered electron.

Before

$\lambda = 2.000 \times 10^{-10}$

$p = \frac{h}{\lambda}$

$p = 3.315 \times 10^{-24}$

e^-

$m = 9.11 \times 10^{-31}$ kg

$v = 0.0$ m/s

$p = 0.0$

After

$\lambda' = 2.049 \times 10^{-10}$ m

$p' = \frac{h}{\lambda}$

$p' = -3.2357... \times 10^{-24}$

e^-

$m = 9.11 \times 10^{-31}$ kg

$v = ?$

$$\Sigma p = \Sigma p'$$

$$3.315 \times 10^{-24} + 0 = -3.2357... \times 10^{-24} + mv$$

$$6.5507... \times 10^{-24} = mv$$

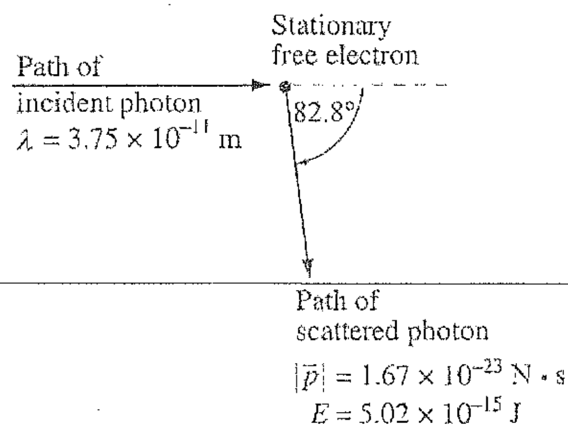
$$\frac{6.5507... \times 10^{-24}}{9.11 \times 10^{-31} \text{ kg}} = v = 7190696.755 \text{ m/s}$$

$v = 7.19 \times 10^{6}$ m/s, east

Use the following information to answer the question.

In an observation of the Compton effect, a photon is incident on a free electron. The scattered photon is detected, as illustrated below. The scattered electron is not shown.

Before **After**



6. Determine the velocity of the scattered electron. Be sure to include a magnitude and a direction.

$\Sigma p_x = \Sigma p_x'$

$p = \frac{h}{\lambda} + 0.0 = p'_{e^-x} + \cos(82.8°)\, p'_{scattered}$

$\frac{6.63\times10^{-34}\,J\cdot s}{3.75\times10^{-11}\,m} = p'_{e^-x} + \cos(82.8°)\, 1.67\times10^{-23}\,N\cdot s$

$1.768\times10^{-23}\,N\cdot s = p'_{e^-,x} + 2.0930...\times10^{-24}\,N\cdot s$

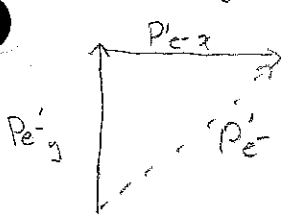
$1.5586...\times10^{-23}\,N\cdot s = p'_{e^-,x}$

$\Sigma p_y = \Sigma p_y'$

$0 + 0 = p'_{e^-y} + -(\sin\theta\, p'_{scattered})$

$0 = p'_{e^-y} - \sin(82.8°)(1.67\times10^{-23}\,N\cdot s)$

$p'_{e^-y} = +1.6568...\times10^{-23}\,N\cdot s$



$p'_{e^-}\ 2.27477...\times10^{-23}\,N\cdot s$

$\theta = \tan^{-1}\left(\frac{p'_{e^-x}}{p'_{e^-,y}}\right) = 43.25°$

$\therefore v = p/m$

$v = \frac{2.27477...\times10^{-23}\,N\cdot s}{9.11\times10^{-31}\,kg}$

$v = 2.50\times10^{7}\,m/s,\ 43.3°$ Entol