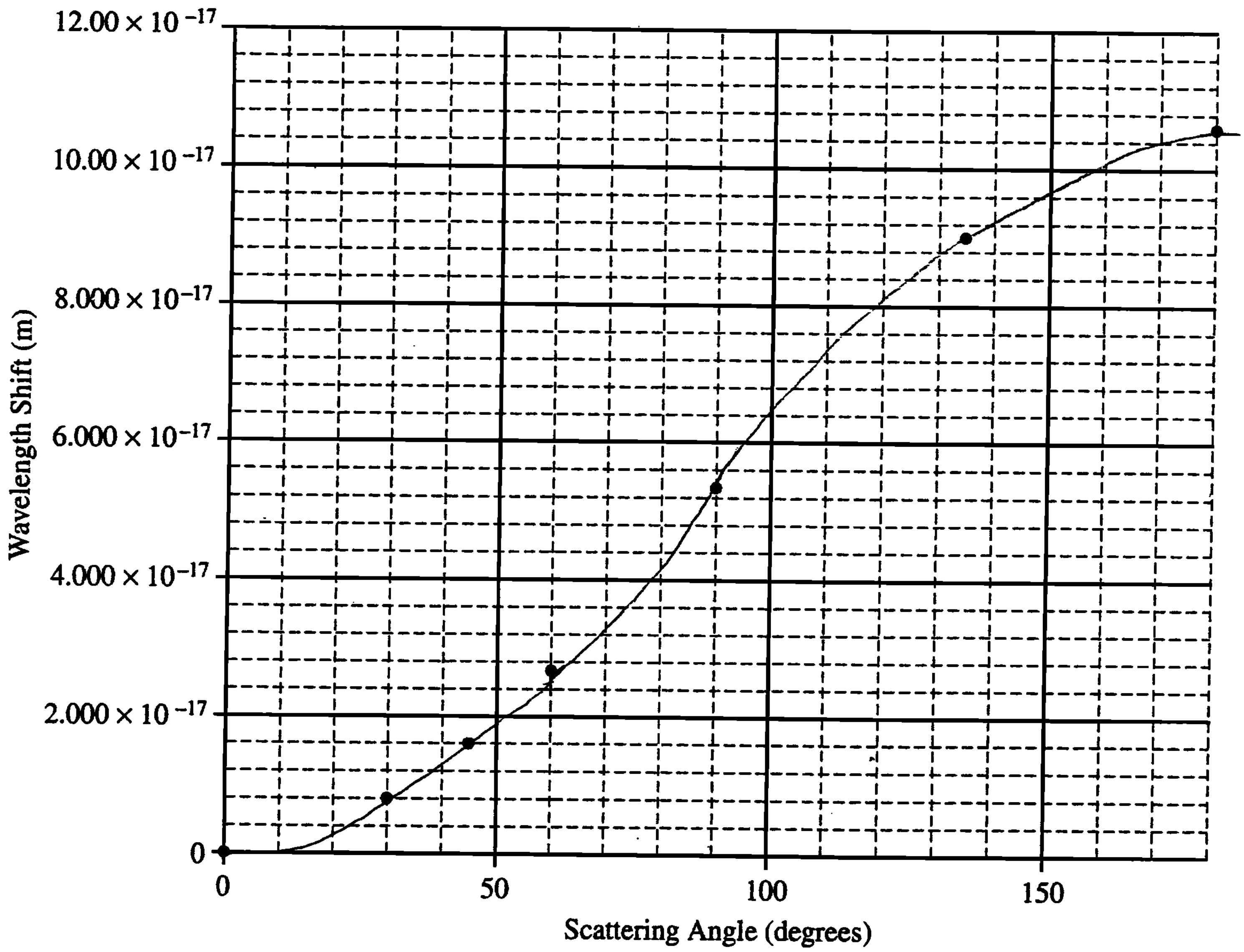
CollegeBoard
Advanced Placement Program

AP® Physics B
2004 Sample Student Responses
Form B

A1

6. (10 points)

An incident gamma ray photon of wavelength 1.400×10^{-14} m is scattered off a stationary nucleus. The shift in wavelength of the photon is measured for various scattering angles, and the results are plotted on the graph shown below.



(a) On the graph, sketch a best-fit curve to the data.

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A2

In one of the trials, the photon is scattered at an angle of 120° with its original direction.

(b) Calculate the wavelength of this photon after it is scattered off the nucleus.

On the graph, the wavelength shift that corresponds to 120° of scattering angle is approximately 8×10^{-17} m.

$$\lambda = 1.4\times10^{-14}\,m + 8\times10^{-17}\,m = 1.408\times10^{-14}\,m$$

(c) Calculate the momentum of this scattered photon.

$$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}\,J\cdot S}{1.408\times10^{-14}\,m} = 4.709\times10^{-20}\,N\cdot S$$

(d) Calculate the energy that this scattering event imparts to the recoiling nucleus.

The frequency of the incident gamma ray photon f_0 is

$$f_0 = \frac{v}{\lambda} = \frac{3\times10^{8}\,m/s}{1.4\times10^{-14}\,m} = 2.14\times10^{22}\,Hz$$

The original energy of the photon is then,

$$E_0 = hf_0 = 6.63\times10^{-34}\,J\cdot S\cdot 2.14\times10^{22}\,Hz$$
$$= 1.421\times10^{-11}\,J$$

The energy of the scattered photon is

$$E_1 = hf_1 = h\frac{v}{\lambda_1} = 6.63\times10^{-34}\,J\cdot s\cdot 3\times10^{8}\,m/s\,/(1.408\times10^{-14}\,m)$$
$$= 1.413\times10^{-11}\,J$$

The energy imparted is

$$E_0 - E_1 = 8\times10^{-14}\,J$$

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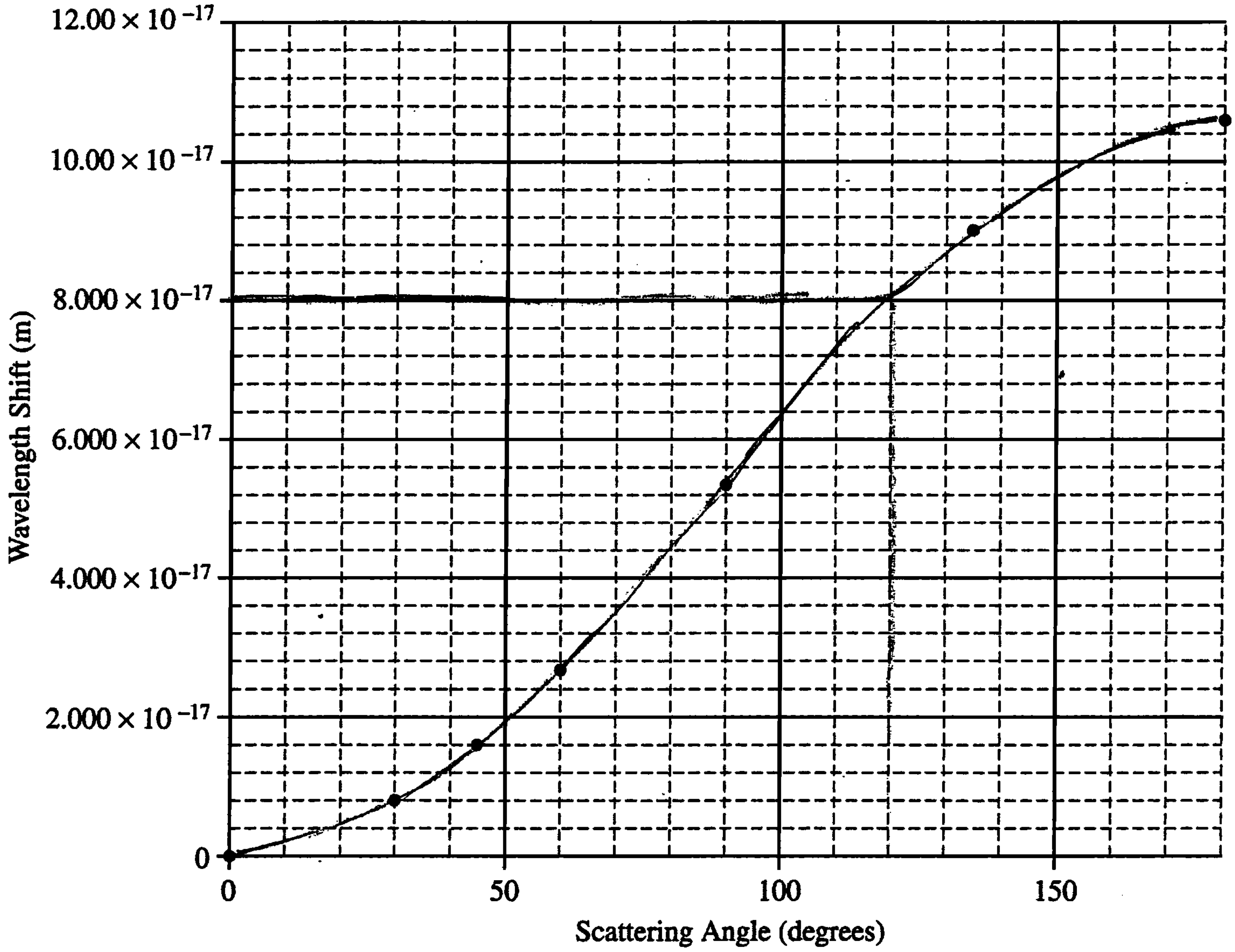
B1

6. (10 points)

An incident gamma ray photon of wavelength 1.400×10^{-14} m is scattered off a stationary nucleus. The shift in wavelength of the photon is measured for various scattering angles, and the results are plotted on the graph shown below.



(a) On the graph, sketch a best-fit curve to the data.

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B2

In one of the trials, the photon is scattered at an angle of 120° with its original direction.

(b) Calculate the wavelength of this photon after it is scattered off the nucleus.

$\lambda = 1.400 \times 10^{-14}\,m + 8.000 \times 10^{-17}\,m$

$= \boxed{1.408 \times 10^{-14}\,m}$

(c) Calculate the momentum of this scattered photon.

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

$= \frac{6.63 \times 10^{-34}\,J \cdot s}{1.408 \times 10^{-14}\,m}$

$= \boxed{4.709 \times 10^{-20}\,kg \cdot m/s}$

(d) Ca ts to the recoil

$E = pc$

$= (4.709 \times 10^{-20}\,kg\,m/s)(3.00 \times 10^{8}\,m/s)$

$= \boxed{1.413 \times 10^{-11}\,J}$

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