



**AP[®] Physics B
2004 Sample Student Responses
Form B**

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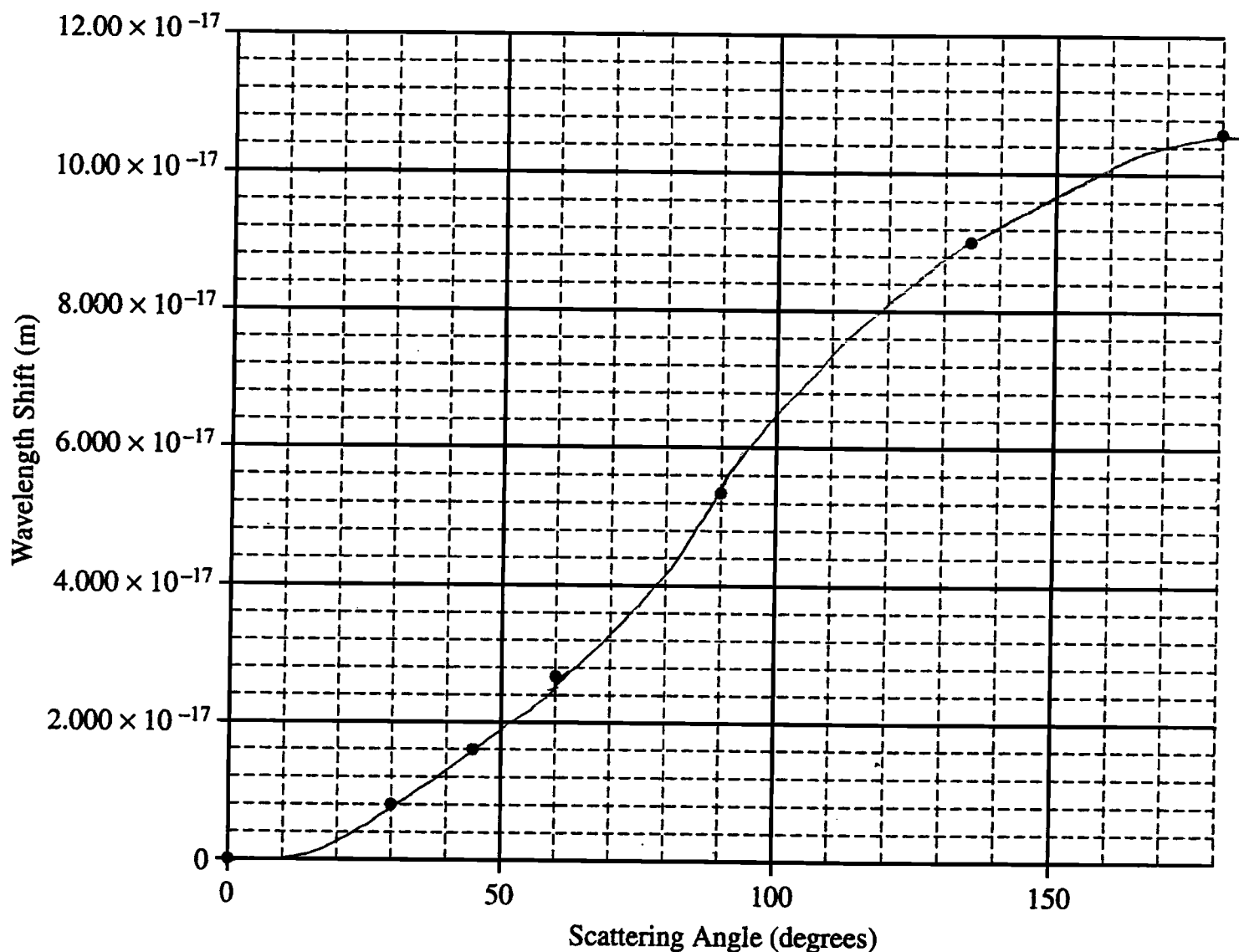
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6. (10 points)

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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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 that corresponds to 120° of scattering angle is approximately $8 \times 10^{-17} \text{ m}$.

$$\lambda = 1.4 \times 10^{-14} \text{ m} + 8 \times 10^{-17} \text{ m} = 1.408 \times 10^{-14} \text{ m}$$

(c) Calculate the momentum of this scattered photon.

$$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{1.408 \times 10^{-14} \text{ m}} = 4.709 \times 10^{-20} \text{ N}\cdot\text{s}$$

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

The frequency of the incident gamma ray photon f_0 is

$$f_0 = \frac{v}{\lambda} = \frac{3 \times 10^8 \text{ m/s}}{1.4 \times 10^{-14} \text{ m}} = 2.14 \times 10^{22} \text{ Hz}$$

The original energy of the photon is then,

$$E_0 = hf_0 = 6.63 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 2.14 \times 10^{22} \text{ Hz} \\ = 1.421 \times 10^{-11} \text{ J}$$

The energy of the scattered photon is

$$E_1 = hf_1 = h \frac{v}{\lambda_1} = 6.63 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3 \times 10^8 \text{ m/s} / (1.408 \times 10^{-14} \text{ m}) \\ = 1.413 \times 10^{-11} \text{ J}$$

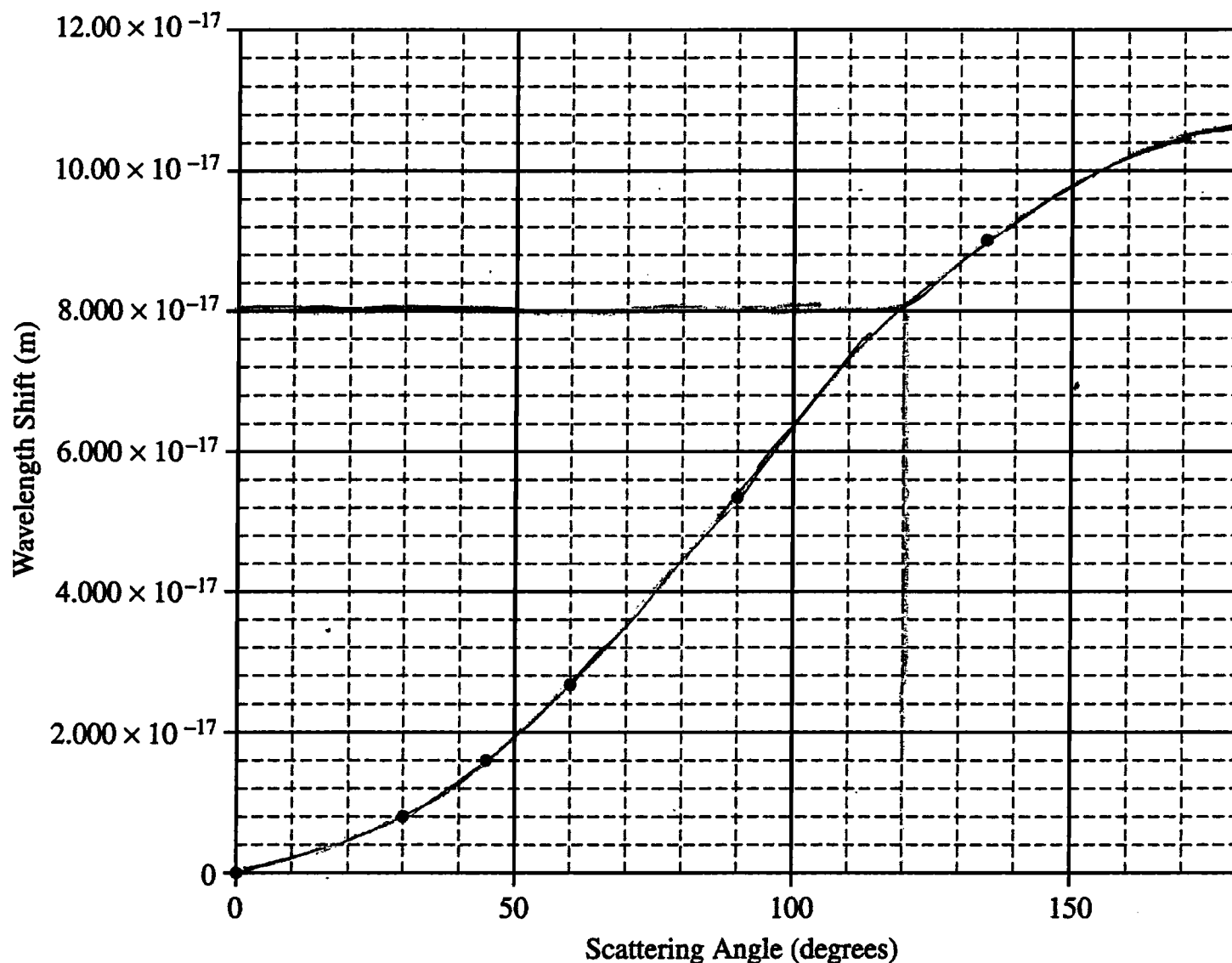
The energy imparted is

$$E_0 - E_1 = 8 \times 10^{-15} \text{ J}$$

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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.

GO ON TO THE NEXT PAGE.

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.

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

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

(c) Calculate the momentum of this scattered photon.

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

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

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

(d) Calculate the energy transferred to the recoil nucleus.

Energy transferred to the recoil nucleus

$$E = pc$$

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

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

GO ON TO THE NEXT PAGE.