12 **(a)** State what is meant by a *photon*.

.....

.....

..... [2]

(b) A stationary nucleus of samarium-157 ($^{157}_{62}$Sm) emits a gamma-ray (γ-ray) photon of energy 0.57 MeV.

Determine, for one γ-ray photon:

(i) its wavelength

wavelength = ... m [2]

(ii) its momentum.

momentum = ... N s [2]

(c) (i) Using your answer to **(b)(ii)**, determine the speed of the samarium-157 nucleus after emission of the photon.

speed = ... $m\,s^{-1}$ [2]

(ii) By reference to your answer in **(c)(i)**, explain quantitatively why the speed of the samarium-157 nucleus may be assumed to be negligible compared with the speed of the photon.

.....

..... [1]

[Total: 9]

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