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

....

....

.... [2]

(b) A stationary nucleus of uranium-238 ($^{238}_{92}U$) undergoes alpha decay to produce a nucleus of thorium-234 ($^{234}_{90}Th$). The kinetic energy of the emitted alpha particle is 4.200 MeV. A gamma-ray photon is also emitted during the decay.

Assume that the rebound kinetic energy of the thorium nucleus is negligible.

Table 8.1 shows the masses of the nuclides involved in the decay reaction. The mass of the uranium-238 nuclide is missing.

Table 8.1

nuclide	nuclide mass / u
$^{4}_{2}\alpha$	4.000407
$^{234}_{90}Th$	233.915174
$^{238}_{92}U$	

The total energy released in the decay of the nucleus of uranium-238 is 4.274 MeV.

(i) Calculate the mass, in u, of the uranium-238 nuclide. Give your answer to five decimal places.

mass = ... u [3]

(ii) Determine a value for the wavelength of the gamma radiation emitted during the decay of the uranium-238 nucleus.

wavelength = ... m [3]

(iii) In practice, the rebound kinetic energy of the thorium nucleus is **not** negligible.

Explain, without further calculation, how your answer in **(b)(ii)** compares with the true wavelength of gamma radiation emitted during the decay of the uranium-238 nucleus.

....

....

.... [1]

(c) Gamma radiation emitted during the decay of a sample of uranium-238 has a single wavelength.

Nuclei of cobalt-60 ($^{60}_{27}Co$) decay by beta emission, and also emit gamma radiation in the process.

Suggest why there is **not** a single wavelength for the gamma radiation emitted during the decay of a sample of cobalt-60.

....

....

.... [2]

[Total: 11]