

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

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.....

..... [2]

(b) A stationary nucleus of uranium-238 ($^{238}_{92}\text{U}$) undergoes alpha decay to produce a nucleus of thorium-234 ($^{234}_{90}\text{Th}$). 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
$^4_2\alpha$	4.000 407
$^{234}_{90}\text{Th}$	233.915 174
$^{238}_{92}\text{U}$	

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.

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..... [1]

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

Nuclei of cobalt-60 (⁶⁰₂₇Co) 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.

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..... [2]

[Total: 11]

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

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..... [2]

(b) A laser emits red light of a single wavelength. The light is produced when electrons move from a higher energy level to a lower energy level. The difference in energy between the two levels is 1.96 eV.

(i) Calculate the wavelength of the light.

wavelength = m [3]

(ii) The power of the beam emitted by the laser is $1.0 \times 10^{-2} \text{ W}$.

Calculate the number of photons emitted per unit time by the laser.

number per unit time = s^{-1} [1]

(iii) The photons are incident normally on a surface. Half of the number of photons are absorbed by the surface, and half are reflected.

Determine the average force exerted by the beam of photons on the surface.

average force = N [4]