20 Caesium-137 is a radioactive isotope produced during the fission of uranium.

(a) State what is meant by fission.

(1)

.....

.....

(b) (i) Caesium-137 decays by emitting beta radiation.

Complete the nuclear equation for the decay of caesium-137.

$$^{137}_{55}\mathrm{Cs} \rightarrow \text{.....}\ \mathrm{Ba} + \text{.....}\ \beta^- + {}^{0}_{0}\overline{\nu}$$

(2)

(ii) Explain why the emission of an antineutrino in the decay leads to a range of energies for the β^- particles.

(2)

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(c) Caesium-137 is a major source of radiation from radioactive waste.

(i) A nuclear fission reactor produces about 24 kg of caesium-137 each year.

A website states that 24 kg of caesium-137 has the same activity as 2000 kg of radium-226.

Assess whether this statement is correct.

half-life of caesium-137 = 30.2 years
mass of a caesium atom = 136.9 u
activity of 2000 kg of radium-226 = 7.33×10^{16} Bq
1 year = 3.15×10^{7} s

(6)

(ii) Caesium-137 may enter plants grown in a contaminated area.

The radiation from 100 g of plant material grown in a contaminated area can have a count rate as high as 500 Bq. A count rate of 150 min^{-1} is considered safe.

Determine the time taken for the count rate from 25 g of plant material grown in a contaminated area to fall to a safe level.

(3)

Time taken = ...

(Total for Question 20 = 14 marks)