Marks
6

- In March 2011 after a tsunami flooded the Fukushima Daiichi nuclear power plant, three of the six reactors went into meltdown, and by 31 March had released large quantities of the nuclides detailed in the table below.

Radioisotope	Initial activity of quantity released (10^{15} Bq)	Half-life
^{131}I	511	8.02 days
^{137}Cs	13.6	30.17 years

Given that the only stable nuclide of iodine is ^{127}I, would you expect the primary decay mechanism for ^{131}I to be α, $β^-$, or $β^+$ decay? Briefly explain your reasoning.

^{131}I has Z = 53 and N = 78 giving an N / Z ratio of 1.47. This ratio suggests that $β^-$ will be the primary decay mechanism. α becomes impoortant after Z = 82.

This decay route will lower this ratio as it involves a neutron being converted into a proton and a $β^-$ particle: N will decrease by 1 and Z will increase by 1.

Calculate the decay constant for ^{131}I.

The decay constant, λ, is related to the half life, $t_{1/2} = \ln 2 / \lambda$:

$$\lambda = \ln 2 / t_{1/2} = \ln 2 / (8.02 \times 24 \times 60 \times 60)\ s^{-1} = 1.00 \times 10^{-6}\ s^{-1}$$

Answer: **$1.00 \times 10^{-6}\ s^{-1}$**

Calculate the initial mass of ^{131}I released.

The initial activity of ^{131}I is 511×10^{15} Bq or 511×10^{15} nuclei s^{-1}. As activity, $A = \lambda N$:

$$N = A / \lambda = 511 \times 10^{15}\ \text{nuclei}\ s^{-1} / 1.00 \times 10^{-6}\ s^{-1} = 5.11 \times 10^{23}\ \text{nuclei}$$

The molar mass of ^{131}I is 131 g mol^{-1} so 6.022×10^{23} nuclei has a mass of 131 g. Therefore:

$$5.11 \times 10^{23}\ \text{nuclei corresponds to}\ 5.11 \times 10^{23} / 6.022 \times 10^{23} \times 131\ g = 111\ g$$

Answer: **111 g**

THIS QUESTION CONTINUES ON THE NEXT PAGE.