Marks 6

- On the 6th of April 2011, after the earthquake and tsunami in Japan, levels of ^{131}I in seawater were recorded at 7.5×10^6 times the legal limit. The half-life of ^{131}I is 8.02 days. How long will it take for the radioactivity of the initially sampled seawater to fall back to the legal limit?

The radioactivity is proportional to the number of radioactive nuclei, $A = \lambda N$. As the number of radioactive nuclei varies with time according to $\ln(N_0/N_t) = \lambda t$:

$$\ln(A_0/A_t) = \lambda t$$

Using $t_{1/2} = \ln 2 / \lambda$:

$$\lambda = \ln 2 / t_{1/2} = \ln 2 / 8.02 \text{ days}^{-1} = 0.0864 \text{ days}^{-1}$$

if $A_0 = 7.5 \times 10^6 \times A_t$,

$$\ln(7.5 \times 10^6) = (0.0864 \text{ days}^{-1}) \times t$$

$$t = 183 \text{ days}$$

Answer: **183 days**

Why is the ^{131}I nucleus unstable?

The $^{131}_{53}I$ nucleus lies outside the zone of stability - its neutron to proton ratio is too high.

Write a balanced equation for a likely decay mechanism of ^{131}I.

$$^{131}_{53}I \rightarrow \ ^{131}_{54}Xe + \ ^{0}_{-1}\beta$$

Another significant seawater contaminant detected after the tsunami was ^{137}Cs, which has a half-life of 30 years. If you were exposed to equal concentrations of both isotopes for 1 hour, which isotope, ^{137}Cs or ^{131}I, would do more damage? Explain your reasoning.

^{131}I would do more damage.

It has the shorter half-life so undergoes more disintegrations and produces more radiation in a given time period.