One method of determining whether further radionuclide leaks are occurring is to monitor the relative activities of the different nuclides as a function of time. Calculate the expected activity due to each of these nuclides exactly 3 years after the release. Assume no more has subsequently escaped from the reactors.

Marks 6

If the initial number of nuclei is N_0, the number of radioactive nucleus after time t is N_t where $\ln(N_0/N_t) = \lambda t$. As $A = \lambda N$, this can also be written in terms of activities:

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

From 2014-J-2, λ for ^{131}I is 1.00×10^{-6} s^{-1} and $A_0 = 511 \times 10^{15}$ Bq. Hence, after exactly 3 years:

$$\ln(511 \times 10^{15}\ \text{Bq} / A_t) = (1.00 \times 10^{-6}\ \text{s}^{-1}) \times (3.00 \times 365.25 \times 24 \times 60 \times 60\ \text{s})$$

$$A_t = 3.80 \times 10^{-24}\ \text{Bq}$$

From 2014-J-2, $t_{1/2} = 30.17$ years for ^{137}Cs. Hence:

$$\lambda = \ln 2 / t_{1/2} = \ln 2 / (30.17 \times 365.25 \times 24 \times 60 \times 60)\ \text{s}^{-1} = 7.28 \times 10^{-10}\ \text{s}^{-1}$$

Using $A_0 = 13.6 \times 10^{15}$ Bq from 2014-J-2, after exactly 3 years:

$$\ln(13.6 \times 10^{15}\ \text{Bq} / A_t) = (7.28 \times 10^{-10}\ \text{s}^{-1}) \times (3.00 \times 365.25 \times 24 \times 60 \times 60\ \text{s})$$

$$A_t = 1.27 \times 10^{16}\ \text{Bq}$$

Activities	^{131}I: **3.80×10^{-24} Bq**	^{137}Cs: **1.27×10^{16} Bq**

Caesium has no biological role in the human body, and is usually only present in trace amounts. On ingestion, even non-radioactive Cs isotopes are considered toxic as they are capable of partially substituting for chemically similar elements. Name a chemically similar element. State one chemically-significant difference between ions of this element and Cs^+ ions.

As a +1 ion, Cs^+ is chemically similar to Na^+ and K^+.

Cs^+ is larger than either of these ions. This will lead it to have higher coordination numbers: more anions will fit around it in ionic solids and more donor atoms (such as OH_2) will coordinate to it than can fit on Na^+ or K^+.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.