Marks 7

- Technetium-99m is an important radionuclide for medical imaging. It is produced from molybdenum-99. Fill in the box below to give a balanced nuclear equation for the production of Tc-99m from Mo-99.

$${}^{99}_{42}\text{Mo} \rightarrow {}^{99m}_{43}\text{Tc} + {}^{0}_{-1}\text{e}$$

The half-life of Tc-99m is 6.0 hours. Calculate the decay constant, λ, in s^{-1}.

The half life, $t_{1/2}$, is equal to:

$$t_{1/2} = \ln 2 / \lambda = \ln 2 / (6.0 \times 60. \times 60.\ s) = 3.2 \times 10^{-5}\ s^{-1}$$

Answer: **$3.2 \times 10^{-5}\ s^{-1}$**

Calculate the molar activity in Bq mol^{-1}.

A mol of Tc-99m contains 6.022×10^{23} nuclei. As activity $A = \lambda N$ where N is the number of nuclei:

$$A = (3.2 \times 10^{-5}\ s^{-1}) \times (6.022 \times 10^{23}\ \text{nuclei mol}^{-1}) = 1.9 \times 10^{19}\ \text{Bq mol}^{-1}$$

Answer: **1.9×10^{19} Bq mol^{-1}**

Calculate the time in hours for 90% of the activity of a sample of Tc-99m to decay.

The number of nuclei changes with time according to $\ln(N_0/N_t) = \lambda t$. If 90% of the nuclei have decayed, $N_t = 0.10 \times N_0$ or $N_0 / N_t = 1 / 0.10$. Hence:

$$\ln(N_0/N_t) = \lambda t$$

$$\ln(1 / 0.10) = (3.2 \times 10^{-5}\ s^{-1}) \times t$$

$$t = 72000\ s = 20\ \text{hours}$$

Answer: **20 hours**

Why is Tc-99m suitable for medical imaging? Give two reasons.

Appropriately short half-life allows time for production of nuclide, administration to patient, and for it to accumulate in the tissue of interest. Activity is high enough to give good quality image with small amount of nuclide.

It is a gamma emitter – highly penetrating radiation that can be detected outside the body and is not damaging to human tissue as it is non-ionising.

Its chemical properties allow it to be incorporated into molecules that will be absorbed by the organs to be investigated.