Deacon's Challenge No. 41 Answer

If the half life of a radionucleotide is 20 hours, at the end of how many complete days will the activity have fallen to less than 2% of the initial value?

Radioactive decay follows the 1st order rate equation:

$$\log_e A_t = \log_e A_0 - kt$$

where A_0 = activity at zero time = 100%

A_t = activity at time 't' = 2%

k = decay constant

The decay constant is related to the half life ($t_{1/2}$):

$$t_{1/2} = \frac{0.693}{k}$$

Therefore, $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{20} = 0.0347h^{-1}$

Substitute values for A_0, At, and k into the first order decay equation and solve for 't':

$$\log_e 2 = \log_e 100 - 0.0347t$$

$$0.693 = 4.605 - 0.0347t$$

$$0.0347t = 4.605 - 0.693 = 3.912$$

$$t = \frac{3.912}{0.0347} = 112.7h$$

Divide by 24 to convert from h to days:

$$t = \frac{112.7}{24} = 4.70 \text{ days}$$

Therefore at least **5** complete days must elapse before the activity will have fallen to less than 2% of the original value.

Exam tip: The 1st order rate equation for radioactive decay (and the relationship between half-life and decay constant) is the same for drug elimination, clearance of a tumour marker etc. ■

Question 42

A mobile phase for an HPLC method is prepared by mixing 100 mL of methanol with 900 mL of buffer. If only 360 mL of buffer is available, how much methanol must be added to obtain the maximum volume of mobile phase?