SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

Approved by AICTE, New Delhi, Affiliated to Anna University, Chennai
Accredited by NAAC-UGC with 'A++' Grade (Cycle III) &
Accredited by NBA (B.E - CSE, EEE, ECE, Mech & B.Tech.IT)
COIMBATORE-641 035, TAMIL NADU

Department of Biomedical Engineering

Course Code & Name: 19BME301 & Medical Physics

III Year : V Semester

Unit III – PRODUCTION OF RADIONUCLIDES

Example 11.1: ***Calculating Mass*** A patient needs iodine (I^{131}) for treatment. What is the mass of iodine in 550 MBq of I^{131} used as therapy dose? Half-life of I^{131} is 8.04 days.

Solution

Half-life of $I^{131} = T_{1/2} = 8.04$ days $= 694{,}000$ s

$\lambda = 0.693/T_{1/2} = 0.693/694{,}000$

$\lambda = 9.985 \times 10^{-7}$ s

Activity $= A = 550$ MBq $= 550 \times 10^6$ disint./s

Activity $= A = \lambda N => N = A/\lambda$

$N = 550 \times 10^6 / 9.985 \times 10^{-7}$

$N = 5.508 \times 10^{14}$

To calculate the mass, we take help of Avogadro's number $N_A = 6.02 \times 10^{23}$ atoms/mole

1 mole of $I^{131} = 131$ g

6.02×10^{23} atoms of I^{131} has mass $= 131$ g

Therefore,

The mass of 5.508×10^{14} atoms of $I^{131} = 131 \times 5.508 \times 10^{14} / 6.02 \times 10^{23}$

Thus, the mass of 550 MBq $I^{131} = 1.2 \times 10^{-7}$ g

Example 11.2: ***Calculating Mass*** What is the mass of 1×10^{-3} Ci of mTc^{99}? mTc^{99} has a decay constant of

$\lambda = 3.2 \times 10^{-5}\ s^{-1}$.

Solution

$\lambda = 3.2 \times 10^{-5}\ s^{-1}$, mass =?

$A = \lambda N = 1 \times 10^{-3}$ Ci

Since 1 Ci $= 3.7 \times 10^{10}$ disint./s, therefore

$A = 1 \times 10^{-3} \times 3.7 \times 10^{10}$

$A = 3.7 \times 10^{7}$ disint./s

Using $A = \lambda N => N = A/\lambda$

$N = 3.7 \times 10^{7}/3.2 \times 10^{-5}$

$N = 1.156 \times 10^{12}$

1 mole of $mTc^{99} = 99$ g

6.02×10^{23} atoms of mTc^{99} has mass $= 99$ g

Therefore,

The mass of 1.156×10^{12} atoms of $mTc^{99} = 99 \times 1.156 \times 10^{12} / 6.02 \times 10^{23}$

Thus, the mass of 1×10^{-3} Ci $mTc^{99} = 1.9 \times 10^{-11}$ g

Example 11.5: Disposal Time A sealed bag of contaminated waste measures 185 MBq. This bag is contaminated by radioactive I^{125} with half-life of 60 days. The permitted activity of I^{125} for waste discharge is 45,000 Bq. How long this contaminated bag should be stored before safe discharge?

Solution

$T_{1/2} = 60$ days $\Rightarrow \lambda = 0.693/60 = 0.01155$ /day, $t = ?$

$N_0 = 185 \times 10^6$ Bq, $N = 4.5 \times 10^4$ Bq

Using $N = N_0.e^{-\lambda t}$

Simplifying $N / N_0 = e^{-\lambda t}$

$N_0 / N = e^{\lambda t}$

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

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

$t = [\ln (185 \times 10^6 / 4.5 \times 10^4)] / 0.01155$

$t = [\ln (4111.11)] / 0.01155$

$t = 8.32 / 0.01155$

$t = 720.5$ days or about 2 years