(17.6) ^{59}Fe of high specific activity can be produced through thermal neutron irradiation of a solution of 1 ml 0.1 M potassium hexacyanoferrate. The recoiling (free) iron atoms, which are produced with a 40% yield, are quantitatively extracted into an organic solvent. How long must the irradiation be in a reactor of $3*10^{19}$ n m^{-2} s^{-1} to obtain 37 MBq ^{59}Fe? The reaction cross-section for $^{58}Fe(n,\gamma)^{59}Fe$ (β,γ 45.1 d) is 1.15 b and the isotopic abundance of ^{58}Fe is 0.3% in natural iron.

First constants and definitions:

$N_A := 6.022137 \cdot 10^{23} \cdot mole^{-1}$ $\quad barn := 10^{-28} \cdot m^2$ $\quad Bq := sec^{-1}$ $\quad M := mole \cdot liter^{-1}$

Then data given in the text and elsewhere:

$t_{half} := 45.1 \cdot day$ $\quad \lambda := \frac{ln(2)}{t_{half}}$ $\quad A_{59Fe} := 37 \cdot 10^6 \cdot Bq$

$\phi := 3 \cdot 10^{19} \cdot m^{-2} \cdot sec^{-1}$ $\quad \sigma := 1.15 \cdot barn$ $\quad volume := 1 \cdot mL$

$conc := 0.1 \cdot M$ $\quad x_{58Fe} := \frac{0.3}{100}$ $\quad \eta := \frac{40}{100}$

Calculations (use a variant of eqn. (17.14)):

$N_{58Fe} := volume \cdot conc \cdot N_A \cdot x_{58Fe}$ $\quad N_{58Fe} = 1.807 \cdot 10^{17}$

$$t_{irr} := -\frac{1}{\lambda} \cdot ln\left(1 - \frac{\frac{A_{59Fe}}{\eta}}{\phi \cdot \sigma \cdot N_{58Fe}}\right)$$ $\quad t_{irr} = 9.031 \cdot 10^5 \cdot sec$ $\quad$ or $\quad t_{irr} = 10.452 \cdot day$