(15.1) ^{24}Na is produced through the reaction ^{26}Mg(d,α)^{24}Na. A 0.2 mm thick magnesium foil is irradiated for 1 h by a current of 130 μA of 22 MeV D^+ ions in a cyclotron. The foil has a much larger area than the cross-section of the beam. What is the specific activity of ^{24}Na if the magnesium foil (3 cm^2) contains 0.003% Na and σ for the reaction is assumed to be 25 mb?

First the usual definition of units and constants:

$q_e := 1.6021773 \cdot 10^{-19} \cdot coul$ $N_A := 6.022137 \cdot 10^{23} \cdot mole^{-1}$ $Bq := sec^{-1}$

$kBq := 1000 \cdot Bq$ $MBq := 1000 \cdot kBq$ $GBq := 1000 \cdot MBq$ $TBq := 1000 \cdot GBq$

$PBq := 1000 \cdot TBq$ $EBq := 1000 \cdot PBq$

Then the values given in the text, etc.:

$M_{Mg} := 24.31 \cdot gm \cdot mole^{-1}$ $\rho_{Mg} := 1.74 \cdot gm \cdot cm^{-3}$ $y_{26Mg} := 11 \cdot \%$

$x := 0.2 \cdot mm$ $t_{irr} := 1 \cdot hr$ $I_D := 130 \cdot \mu A$ $\sigma := 25 \cdot 10^{-3} \cdot 10^{-28} \cdot m^2$

$t_{half} := 14.96 \cdot hr$ $area := 3 \cdot cm^2$ $c_{Na} := 0.003 \cdot \%$

Calculations:

$$\phi := \frac{I_D}{1 \cdot q_e} \qquad \lambda := \frac{ln(2)}{t_{half}} \qquad N_{vX} := \frac{\rho_{Mg} \cdot x \cdot y_{26Mg}}{M_{Mg}} \cdot N_A$$

$R_{24Na} := \phi \cdot \sigma \cdot N_{vX} \cdot \left(1 - exp\left(-t_{irr} \cdot \lambda\right)\right)$ eqn. (15.9) with $t_{cool} = 0$

$volume := x \cdot area$ $mass := \rho_{Mg} \cdot volume$ $weight_{Na} := c_{Na} \cdot mass$

$$S_{Na} := \frac{R_{24Na}}{weight_{Na}} \qquad S_{Na} = 28 \cdot \frac{PBq}{kg}$$

Answer: 28 PBq/kg Na