(9.9) A plastic scintillation detector was to be calibrated for absolute measurements of β-radiation. For this purpose a $2.13*10^{-5}$ M $^{204}TlCl_3$ solution was available with a specific activity of 13.93 μCi ml^{-1}; ^{204}Tl emits β-particles with E_{max} 0.77 MeV. Of this solution 0.1 ml is evaporated over an area of exactly 0.1 cm^2 on a platinum foil. The sample is counted in an evacuated vessel at a distance of 15.3 cm from the detector, which has a sensitive area of 1.72 cm^2. The detector registers 2052 cpm with a background of 6 cpm. What is (a) the surface weight of the sample, (b) the backscattering factor, and (c) the detector efficiency for the particular β's?

General constants:

$Bq := sec^{-1}$ $\quad Ci := 3.5 \cdot 10^{10} \cdot Bq$ $\quad M := \frac{mole}{liter}$ $\quad$ For $TlCl_3$: $\quad M_w := (204 + 3 \cdot 35.45) \cdot \frac{gm}{mole}$

Given in the text are:

$c := 2.13 \cdot 10^{-5} \cdot \frac{mole}{liter}$ $\quad S := 13.93 \cdot 10^{-6} \cdot \frac{Ci}{mL}$ $\quad S = 4.875 \cdot 10^{5} \cdot \frac{Bq}{mL}$

$v := 0.1 \cdot 10^{-3} \cdot liter$ $\quad A := v \cdot S$

$mass := v \cdot c \cdot M_w \cdot 10^{-3}$ $\quad mass = 6.61 \cdot 10^{-13} \cdot kg$ $\quad area := 0.1 \cdot 10^{-4} \cdot m^2$

$R_0 := \frac{6}{60} \cdot Bq$ $\quad R := \frac{2052}{60} \cdot Bq$ $\quad R_{net} := R - R_0$ $\quad R_{net} = 34.1 \cdot Bq$

$area_{det} := 1.72 \cdot 10^{-4} \cdot m^2$ $\quad dist := 15.3 \cdot 10^{-2} \cdot m$

(a) $m_{surf} := \frac{mass}{area}$ $\quad m_{surf} = 6.61 \cdot 10^{-8} \cdot kg \cdot m^{-2}$ $\quad m_{surf} = 6.61 \cdot 10^{-6} \cdot \frac{mg}{cm^2}$

(b) Z for Pt is 78. From Fig. 7.14 we get the following data:

$i := 1 .. 4$

$E\beta_i :=$

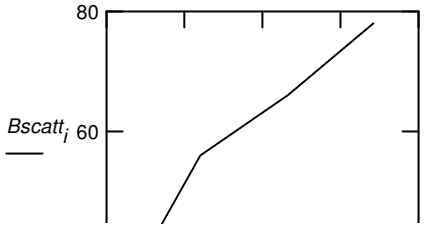
0.32
0.60
1.16
1.71

$Bscatt_i :=$

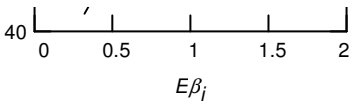
43
56
66
78

For E 0.77 MeV backscatter is about 58.7%, see graph.

$\psi_{back} := 0.587 + 1$



$\psi_{back} = 1.587$



(c) $\psi_{self} := 1$ $\psi_{abs} := 1$ $\psi_{res} := 1$ $\psi_{geom} := \frac{area_{det}}{4 \cdot \pi \cdot dist^2}$ $\psi_{geom} = 5.847 \cdot 10^{-4}$

$\psi := \frac{R_{net}}{A}$ $\psi = 6.994 \cdot 10^{-4}$ $\psi_{det} := \frac{\psi}{\psi_{res} \cdot \psi_{geom} \cdot \psi_{back} \cdot \psi_{self} \psi_{abs}}$ $\psi_{det} = 0.754$