(8.9) 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:

$Bq := sec^{-1}$ $\quad Ci := 3.7\cdot 10^{10}\cdot Bq$ $\quad M := \frac{mole}{liter}$ $\quad$ For $TlCl_3$: $\quad M_w := (204 + 3\cdot 35.45)\cdot\frac{gm}{mole}$

Given in the text are:

$c := 2.13\cdot 10^{-5}\cdot\frac{mole}{liter}$ $\quad S := 13.93\cdot 10^{-6}\cdot\frac{Ci}{mL}$ $\quad S = 5.15\cdot 10^{5}\cdot\frac{Bq}{mL}$

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

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

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

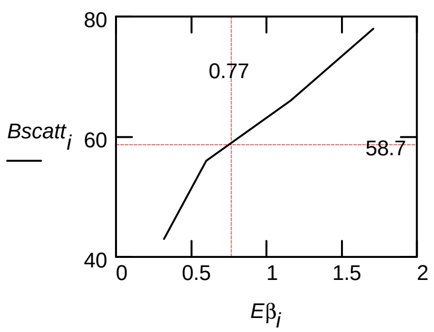
$area_{det} := 1.72\cdot 10^{-4}\cdot m^2$ $\quad dist := 15.3\cdot 10^{-2}\cdot m$

(a) $\quad m_{surf} := \frac{mass}{area}$ $\quad m_{surf} = 6.61\cdot 10^{-5}\cdot kg\cdot m^{-2}$ $\quad m_{surf} = 6.6\cdot 10^{-3}\cdot\frac{mg}{cm^2}$

(b) *Z* for Pt is 78. From Fig. 6.14 we can read off the following data to use in an interpolation:

$i := 1 .. 4$

$E\beta_i :=$	$Bscatt_i :=$
0.32	43
0.60	56
1.16	66
1.71	78



For *E* 0.77 MeV backscatter is about 58.7%, see graph to the right.

$\psi_{back} := 0.587 + 1$ $\quad \psi_{back} = 1.59$

In order to use the backscatter correction as an efficiency factor we must add one to the relative amount of backscattered radiation.

(c) $\psi_{self} := 1$ $\psi_{abs} := 1$ $\psi_{res} := 1$

$$\psi_{geom} := \frac{area_{det}}{4 \cdot \pi \cdot dist^2}$$

$\psi_{geom} = 5.85 \cdot 10^{-4}$

$$\psi := \frac{R_{net}}{A}$$

$\psi = 6.62 \cdot 10^{-4}$

$$\psi_{det} := \frac{\psi}{\psi_{res} \cdot \psi_{geom} \cdot \psi_{back} \cdot \psi_{self} \cdot \psi_{abs}}$$

$\psi_{det} = 0.71$

or

$\psi_{det} = 71 \cdot \%$