(12.4) In Rutherford scattering on a silver foil using α-particles from a thin-walled radon tube, the following data were observed: dσ/dΩ = 22(θ 150º), 47(105º), 320(60º), 5260(30º), 105400(15º) barns per steradian. Calculate the energy of the incident α-particles.

Use eqn (12.17) $d\sigma/d\Omega=(k*Z_1*Z_2*\boldsymbol{e}^2/(2*m_{red}*(v_1{}^0)^2))^2/\sin^4(\theta/2)$ and then $E_{kin}=m*v^2/2$:

Define some useful constants and units:

$\varepsilon_0 := 8.8541878\cdot 10^{-12}\cdot\frac{coul}{volt\cdot m}$ $\quad q_e := 1.6021773\cdot 10^{-19}\cdot coul$ $\quad u_n := 1.660540\cdot 10^{-27}\cdot kg$

$barn := 10^{-28}\cdot m^2$ $\quad M_{Ag} := 107.87\cdot u_n$

Calculations:

$k := \frac{1}{4\cdot\pi\cdot\varepsilon_0}$ $\quad k$ in eqn. (12.12)

$M_\alpha := \left(4.002603 - 2\cdot 5.4857990\cdot 10^{-4}\right)\cdot u_n$ $\quad (\alpha = He^{2+})$

$m_{red} := \frac{1}{\left(\frac{1}{M_{Ag}}+\frac{1}{M_\alpha}\right)}$ $\quad Z_1 := 2$ $\quad Z_2 := 47$ $\quad m_{red} = 6.407\cdot 10^{-27}\cdot kg$

$k = 8.988\cdot 10^{9}\cdot kg\cdot m^{3}\cdot sec^{-2}\cdot coul^{-2}$

$i := 1..5$

$d\sigma d\Omega_i :=$ $\quad \theta_i :=$ $\quad \theta r_i := \theta_i\cdot\frac{\pi}{180}$

$d\sigma d\Omega_i$	θ_i
22	150
47	105
320	60
5260	30
105400	15

$v_{1_i} := \sqrt{\frac{k\cdot Z_1\cdot Z_2\cdot q_e^{\,2}}{2\cdot m_{red}\cdot\sqrt{\left(barn\cdot d\sigma d\Omega_i\right)}\cdot\sin\left(\frac{\theta r_i}{2}\right)\cdot\sin\left(\frac{\theta r_i}{2}\right)}}$

v_1

$6.219\cdot 10^{6}\cdot m\cdot sec^{-1}$
$6.263\cdot 10^{6}\cdot m\cdot sec^{-1}$
$6.152\cdot 10^{6}\cdot m\cdot sec^{-1}$
$5.902\cdot 10^{6}\cdot m\cdot sec^{-1}$
$5.532\cdot 10^{6}\cdot m\cdot sec^{-1}$

$v_{avg} := \frac{\sum_{i=1}^{5} v_{1_i}}{5}$

$v_{avg} = 6.013\cdot 10^{6}\cdot m\cdot sec^{-1}$

$E_{avg} := \frac{1}{2}\cdot M_\alpha\cdot v_{avg}^{\,2}$

$E_{avg} = 1.201\cdot 10^{-13}\cdot joule$

$= \frac{1.201\cdot 10^{-13}\cdot coul}{q_e} = 7.5\cdot 10^{5}$ eV