(16.8) A thin Au target is irradiated with a beam of 800 MeV $^{16}O^{2+}$ ions during 2 hours. After the irradiaten a faraday cup (with current integrator) behind the target showed a total accumulated charge of 92.3 μC. What was the average beam intensity (oxygen ions per second)? Consider charge-stripping in the target.

Definitions:

$q_e := 1.6021773 \cdot 10^{-19} \cdot coul$

$N_A := 6.022137 \cdot 10^{23} \cdot mole^{-1}$

$c_{light} := 299792458 \cdot m \cdot sec^{-1}$

$m_e := 9.109390 \cdot 10^{-31} \cdot kg$

$M_{16O} := 15.994915 \cdot gm \cdot mole^{-1}$

$MeV := 1.6021773 \cdot 10^{-13} \cdot joule$

$$m_{0Oion} := \frac{M_{16O}}{N_A} - 2 \cdot m_e$$

The rest mass of $^{16}O^{2+}$ ions

Then compute the mass of $^{16}O^{2+}$ ions at 800 MeV kinetic energy by using eqn. (5.26)

$E_{Oion} := 800 \cdot MeV$

$$m_{Oion} := m_{0Oion} + \frac{E_{Oion}}{c_{light}^{2}}$$

Then use eqn (4.19) to compute β with $\beta=(v/\boldsymbol{c})^2$ and v from $v=\beta^*\boldsymbol{c}$:

$$\beta := \sqrt{1 - \left(\frac{m_{0Oion}}{m_{Oion}}\right)^2}$$

$\beta = 0.315$

$v_{Oion} := \beta \cdot c_{light}$

When the velocity is known, we can use eqn. (16.3) to compute the effective charge after passage of the target foil.:

$Z := 8$ $\quad k := 3.6 \cdot 10^{6} \cdot m \cdot sec^{-1}$ $\quad Q := 92.3 \cdot 10^{-6} \cdot coul$

$$z_{eff} := Z \cdot \left[1 + \left(\frac{v_{Oion}}{k \cdot Z^{0.45}}\right)^{-1.67}\right]^{-0.6}$$

$z_{eff} = 7.904$

Once we know the effective average charge of an ion hitting the faraday cup, we can compute the number of ions per unit time as follows:

$t_{irr} := 2 \cdot hr$

$$I_{ion} := \frac{Q}{t_{irr} \cdot z_{eff} \cdot q_e}$$

$I_{ion} = 1.012 \cdot 10^{10} \cdot sec^{-1}$