4-2 $\alpha \longrightarrow 7.7\ \text{MeV}$

$m = 4\,\text{amu}$ $\qquad c^2 = 931.5\ \frac{\text{MeV}}{\text{amu}}$

a) classically

$$KE = \tfrac{1}{2} m v^2$$

$$\left[(7.7\times10^6)(1.602\text{-}19\ \tfrac{J}{eV})\right] = \tfrac{1}{2}\left[4 \cdot 1.67\times10^{-27}\,kg\right] v^2$$

$$v = 1.9218\times10^7\ m/s$$

or

$$\beta = \frac{v}{c} = 6.4059\times10^{-2}$$

b) Relativistic

$$KE = (\gamma - 1)\, mc^2$$

$$7.7\ \text{MeV} = (\gamma - 1)\left[4 \cdot 931.5\ \text{MeV}\right]$$

$$\gamma - 1 = 2.0666\times10^{-3}$$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

$$\gamma = 1.002067$$

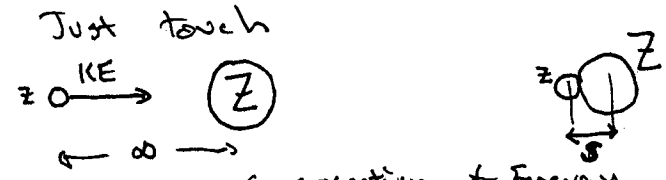
$$\beta = 6.4189\times10^{-2}$$

Fractional Difference

$$\frac{6.4189 - 6.4059}{6.4189} = 2.03\times10^{-3}$$

$$\approx 0.2\%$$

4-11 Just touch



Conservation of Energy

Initial Energy = Final Energy

$$\frac{1}{2} m v^2 = \frac{1}{4\pi\epsilon_0}\frac{ze\,Ze}{s}$$ Coulomb Energy

a) Energy for α-particle to just touch Al & Au

Al $r = 3.6\,fm$ $\quad Z = 13 \rightarrow s = 6.2\ fm$

Au $r = 7.0\,fm$ $\quad = 79 \rightarrow s = 9.6\ fm$

α $r = 2.6\,fm$ $\quad z = 2$

$$m_\alpha = 4 \cdot 1.67\times10^{-27}\ kg$$

b) Repeat for proton to just touch Al & Au

		z	Z	final separation (fm)	final separation (m)	Coulomb Energy when touch (J)	Coulomb Energy when touch (eV)	Coulomb Energy when touch (MeV)
alpha	Al	2	13	6.2	6.2E-15	9.69E-13	6.05E+06	6.1
alpha	Au	2	79	9.6	9.6E-15	3.80E-12	2.38E+07	23.8
proton	Al	1	13	4.9	4.9E-15	6.13E-13	3.83E+06	3.8
proton	Au	1	79	8.3	8.3E-15	2.20E-12	1.37E+07	13.7

4-14 Classical Atomic Model
Hydrogen

use orbit radius $= 1.2 \times 10^{-15}$ m
$m_e = 9.1 \times 10^{-31}$ kg

from our notes (which I hope you have in your notebook)

$$V^2 = \frac{e}{4\pi\epsilon_0 m r} = \frac{1.60\text{-}19}{4\pi(8.85\text{-}12)(9.1\text{-}31)(1.2\times10^{-15})}$$

$$V = 3.4 \times 10^{12} \text{ m/s}$$

which is waaayy bigger than speed of light

$$E_{TOT} = \frac{-e^2}{8\pi\epsilon_0 r} = \frac{-(1.609\text{-}19)^2}{8\pi(8.85\text{-}12)(1.2\text{-}15)}$$

$$= 9.62 \times 10^{-4} \text{ J}$$

$$= 6 \times 10^5 \text{ MeV}$$

Hard to judge this number in our daily experience, but it is rediculously large.