Physics 220 Assignment 7

1. (7.54) gap of 4 nm, with $U_0 - E = 3\,eV$ for electron

probability of tunneling through gap $P \approx e^{-2\alpha L}$

$L = 4\,nm$

$$\alpha = \sqrt{\frac{2m(U_0-E)}{\hbar^2}} = \sqrt{\frac{2mc^2(U_0-E)}{(\hbar c)^2}}$$

$$= \sqrt{\frac{2(511000\,eV)(3\,eV)}{(197\,eV\cdot nm)^2}} = 8.89\,/nm$$

so $P \approx e^{-2\alpha L} = e^{-2(8.89\,/nm)(4\,nm)} = 1.3\times10^{-31}$

2a) (7.55) barrier width $L \approx 35$ fm

barrier height $U_0 - E \approx 5$ MeV

alpha particle (^4He nucleus) $mc^2 = (4.00\times931.5\,\frac{MeV/c^2}{u})c^2 = 3726$ MeV

so $P \approx e^{-2\alpha L}$

and $\alpha = \sqrt{\frac{2mc^2(U_0-E)}{(\hbar c)^2}}$

$$= \sqrt{\frac{2(3726\,MeV)(5\,MeV)}{(197\,MeV\cdot fm)^2}} = 0.98\,/fm$$

$P = e^{-2(0.98\,/fm)(35\,fm)} = 1.6\times10^{-30}$

(chance/hit)

if it hits surface 5×10^{21} times/s, chance of escaping = P * # hits

$= (1.6\times10^{-30})(5\times10^{21}\,/s)(3600\,s/hr)(24\,hr/day) = 7\times10^{-4}$ chance in 1 day

b) if $U_0 - E = 4$ MeV, $\alpha = 0.88 \Rightarrow P = 2.3\times10^{-27}$

about 1000 times more likely!

3. (7.61) see Mathematica notebook