Physics 4271 HW 2

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Problem 1. *Calculate the minimum energy required to be over the Coulomb barrier for:*

1. $\mathrm{p} + \mathrm{p}$,
2. $\mathrm{p} + {}^{12}\mathrm{C}$,
3. ${}^{4}\mathrm{He} + {}^{208}\mathrm{Pb}$.

Problem 2. *The cross section for charged-particle reactions is proportional to the probability of tunneling through the Coulomb barrier given by the Gamow factor, which haas a convenient approximation:*

$$e^{-2\pi\eta} = e^{-2\pi ZZZ_1Z_2e^2/\hbar\nu} = e^{-31.287Z_1Z_2\sqrt{\mu/E}}$$

where μ is the reduced mass in amu and E is the center-of-mass energy in keV. For the 3 cases you considered above, calculate the Gamow factor for an energy that is one-quarter the barrier energy you found in problem 1.,

Problem 3. *A 2 MeV beam of protons bombards a ^{16}O target and the differential cross section is measured to be 0.094 b/sr at a lab angle of $167°$.*

1. *What is the expected cross section if you assume Rutherford scattering?*
2. *What is the calculated Mott cross section?*
3. *How do your answers to (a) and (b) differ from the measured cross section and why might they be different?*

Problem 4. *Assume that ${}^{197}Au$ is made from a solid, uniform sphere of nuclear material with a radius of $R = 1.2\,\mathrm{fm} \cdot A^{1/3}$. Calculate the form factor $F(q)$.*

Problem 5. *Show that the mean-square charge radius of a uniformly charged sphere is $\langle r^2 \rangle = 3R^2/5$.*

Problem 6. *A nuclear charge distribution more realistic than the uniformly charged distribution is the Fermi distribution, $\rho(r) = \frac{\rho_0}{1+\exp[(r-c)/a]}$. Find the value of a if $t = 2.3\,\mathrm{fm}$*

Problem 7 (Bonus)**.** *Evaluate $\langle r^2 \rangle$ for the Fermi distribution in Problem 6.*