Name ______________________________

Exam Advanced Nuclear Physics 03/09/2019 09:00

Question: Nuclear Reactions

These questions will be evaluated on 20 points. You require a minimum of 7/20 points on this part to pass the course. The points will be rescaled to a weight of 6 towards your final grade for the course.
You are not allowed any book or notes.
You may use a calculator and the given list of formulas for this part of the examination.
Write your answers in the boxes; the rest of the space (back side of the sheets) will not be evaluated.

A beam of α particles is directed on a thin ^{12}C foil, at an energy $E_{\mathrm{lab}} = 8\,\mathrm{MeV}$.
[$Z(\mathrm{C}) = 6$; $\Delta(\alpha) = 2.425\,\mathrm{MeV}$, $\Delta(^{12}\mathrm{C}) = 0.000\,\mathrm{MeV}$; use $r_0 = 1.6\,\mathrm{fm}$.]

1. (3/20) Which sort of interaction(s) do you expect to be relevant in the reaction? (Hint: consider the distance of closest approach.)

2. (3/20) We use an optical model (a potential) to calculate the elastic cross section, by solving the radial Schrödinger equation in partial waves.
   How many waves do you expect to contribute to the nuclear part of the cross section? Explain.

3. (3/20) The solution of the Schrödinger equation provides the values of the elastic partial waves scattering amplitudes given in the table below.
   Is strong absorption a good approximation in this case? Explain.

ℓ	$\mathrm{Re}\,\eta_\ell$	$\mathrm{Im}\,\eta_\ell$
0	−0.04	0.04
1	−0.13	−0.02
2	−0.04	−0.10
3	0.18	−0.17
4	0.36	−0.06
5	0.70	0.12
6	0.92	0.08
≥ 7	1.00	0.00

Consider now the fusion channel: α + ^{12}C $\rightarrow$ ^{16}O.
[$\Delta(^{16}\text{O}) = -4.737\,\text{MeV}$.]

4. (4/20) Calculate the excitation energy of the compound nucleus.

5. (3/20) Calculate the fusion (= reaction) cross section using the values of η_ℓ given in question 3.
   Then, calculate the fusion cross section using the sharp cut-off model, with the number of partial waves evaluated in question 2.
   Compare and comment.

6. (4/20) Describe an experimental set-up that could be used to measure the fusion channel $\alpha + {}^{12}C \rightarrow {}^{16}O$.