Name _____

Exam Advanced Nuclear Physics 27/08/2020 08:00

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 under the questions; you may use the back of the sheets as scrap paper.

Consider the collision between α particles and ^{208}Pb at an energy $E_{\text{lab}} = 28.6\,\text{MeV}$. [Use $r_0 = 1.5\,\text{fm}$ for the calculations.]

1. (4/20) Describe an experimental set-up that could be used to identify and measure the events in the elastic scattering channel as a function of the angle. Make a drawing if it helps.

2. (5/20) Which sort of interaction(s) do you expect to be relevant in the collision? (Hint: consider the distance of closest approach.)

3. (4/20) We use an optical model (a potential) to calculate the elastic cross section, by solving the radial Schrödinger equation in partial waves.
   How many partial waves do you expect to contribute to the nuclear part of the cross section? Explain.

4. (3/20) The solution of the Schrödinger equation provides the values of the elastic partial waves scattering amplitudes given in the tables below.
   Is strong absorption a good approximation in this case? Explain.

ℓ	$\mathrm{Re}\,\eta_\ell$	$\mathrm{Im}\,\eta_\ell$
0	−0.03	−0.02
1	−0.03	−0.02
2	−0.03	−0.03
3	−0.03	−0.04
4	−0.02	−0.05
5	0.00	−0.06
6	0.03	−0.07
7	0.07	−0.07
8	0.12	−0.06
9	0.18	−0.03

ℓ	$\mathrm{Re}\,\eta_\ell$	$\mathrm{Im}\,\eta_\ell$
10	0.25	0.03
11	0.36	0.10
12	0.50	0.18
13	0.67	0.22
14	0.82	0.19
15	0.92	0.13
16	0.96	0.08
17	0.98	0.04
18	0.99	0.02
≥ 19	1.00	0.00

5. (4/20) Make a graph of the expected elastic scattering cross section as a function of the centre-of-mass angle. Label the axes correctly.
   Explain why do you expect such a behaviour. Indicate quantities (expected values of the cross section) where possible.