Name ______________________________

Exam Advanced Nuclear Physics 21/01/2019 9:00

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.

Consider the reaction: d+^{40}Ca, measured at a beam energy (in the laboratory) of 29 MeV (for example, as in J.D. Cossairt et al., Phys. Rev. C 18 (1978) 23).

1. (2/20) Consider the inelastic scattering channel ^{40}Ca(d,d')^{40}Ca*.
   Up to which excitation energy can we populate states in ^{40}Ca*?

2. (4/20) Consider now the fusion reaction: $d + {}^{40}\mathrm{Ca} \rightarrow {}^{42}\mathrm{Sc}^*$. [Atomic mass excesses: $\Delta({}^{40}\mathrm{Ca}) = -34.846\,\mathrm{MeV}$, $\Delta(d) = 13.136\,\mathrm{MeV}$, $\Delta({}^{42}\mathrm{Sc}) = -32.121\,\mathrm{MeV}$.]
   - At which excitation energy is ${}^{42}\mathrm{Sc}^*$ produced?
   - What is the kinetic energy of ${}^{42}\mathrm{Sc}^*$?
   - Estimate the highest angular momentum with which we could expect to form ${}^{42}\mathrm{Sc}^*$, and explain why.
   [$Z(\mathrm{Ca}) = 20$; $J^{\pi}(d) = 1^{+}$; for the calculations use $R = 1.6 \times A_{\mathrm{target}}^{1/3}$ fm.]

3. (3/20) Use the strong absorption model (is this fully justified here? explain), and approximate the fusion reaction cross section by the total reaction σ_{r}. Calculate the yield of fusion events in an hour, for a beam intensity $I = 10^8$ particles per second and a target thickness $\rho\Delta x = 50\,\mu\mathrm{g/cm}^2$.

Consider now the channel: ^{40}Ca(d,^{3}He)^{39}K.

4. (5/20) Consider the sequence of low-lying states in ^{39}K:

E^* (^{39}K) (MeV)	J^π
0.0	$3/2^+$
2.522	$1/2^+$
2.814	$7/2^-$
3.019	$3/2^-$

Which states do you expect to be populated in the reaction, assuming a shell-model picture? Explain why.

5. (4/20) For each populated state deduce the expected transferred angular momentum l.
   Deduce quantitatively the expected angle of the first maximum of the corresponding angular distributions [use $r_0 = 1.6\,\mathrm{fm}$; $Q_{gg} = -2.835\,\mathrm{MeV}$).

6. (2/20) Briefly describe an experimental setup that could be used to measure the angular distribution of the ^{40}Ca(d,^{3}He)^{39}K reaction. Add a sketch if useful.