Name _ ______________________

Exam Advanced Nuclear Physics 11/01/2016

Question: Nuclear Reactions

These four question will be evaluated on 20 points. You require a minimum of 7/20 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. Please use the attached sheets of papers for your answer; any additional sheet will be discarded.

Consider Figures 1 and 2 on the following page.

a) For each figure, explain:
- how were the experimental points obtained;
- which type of reactions determines the observed events;
- what is the meaning of the peaks.

For Figure 1 only:
- the data of the Figure were collected at an angle $\theta = 166°35'$ as indicated, however the authors have measured data at a number of different angles. Explain the meaning of the curve "Fit from the analysis of the angular distributions" and which information such analysis provides.

b) Explain briefly the relevance of this kind of reactions in nuclear research, its advantages and its limitations.

c) Consider the diagram of states in ^{16}O as given in Figure 3. Using the information on the diagram, identify the states corresponding to the marked peaks in Figure 2.

d) Consider the peak in Figure 1 at $E_\alpha = 4.264\,\mathrm{MeV}$. The authors of Figure 1 measured a total width for this resonance of $\Gamma_{\mathrm{tot}} = 33\,\mathrm{keV}$, and the authors of Figure 2 measured a radiative width $\Gamma_\gamma = 0.046\,\mathrm{eV}$. There are no other exit channels. Taking into account the spin of the populated state and the initial spins $I_\alpha = 0$ and $I_{^{12}C} = 0$, calculate:
- the resonant part of the elastic cross section $\sigma_{\mathrm{el,res}}$ at the resonance energy;
- the radiative cross section σ_γ at the resonance energy;
- the non-resonant part of the elastic cross section $\sigma_{\mathrm{el,pot}}$ at the resonance energy (without including the Coulomb cross section).

For the channel radius use the interaction radius $1.3 \times (A_1^{1/3} + A_2^{1/3})$ fm.

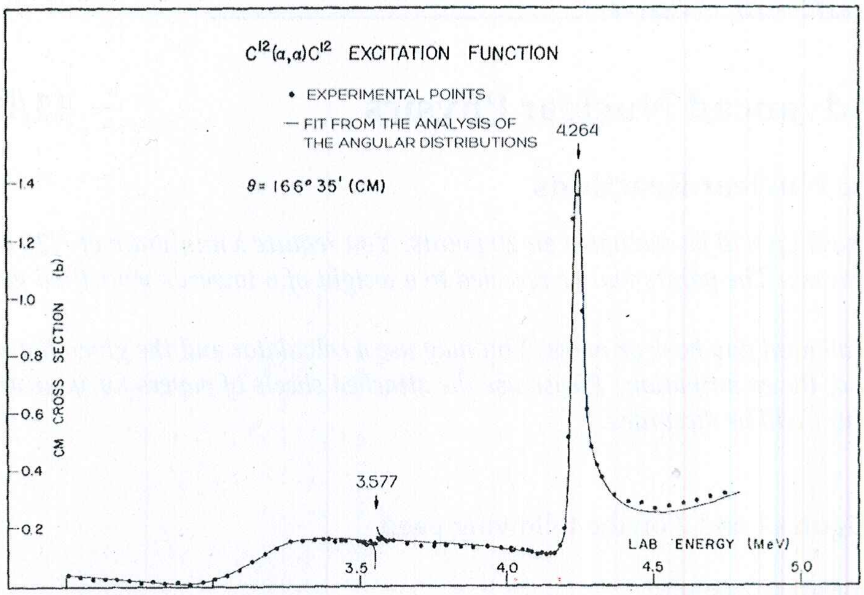

Figure 1: Yield of α particles (cross section) for the $^{12}C(\alpha,\alpha)^{12}C$ reaction as function of bombarding energy. Adapted from C. Miller Jones et al., Nucl. Phys. 37 (1962) 1.

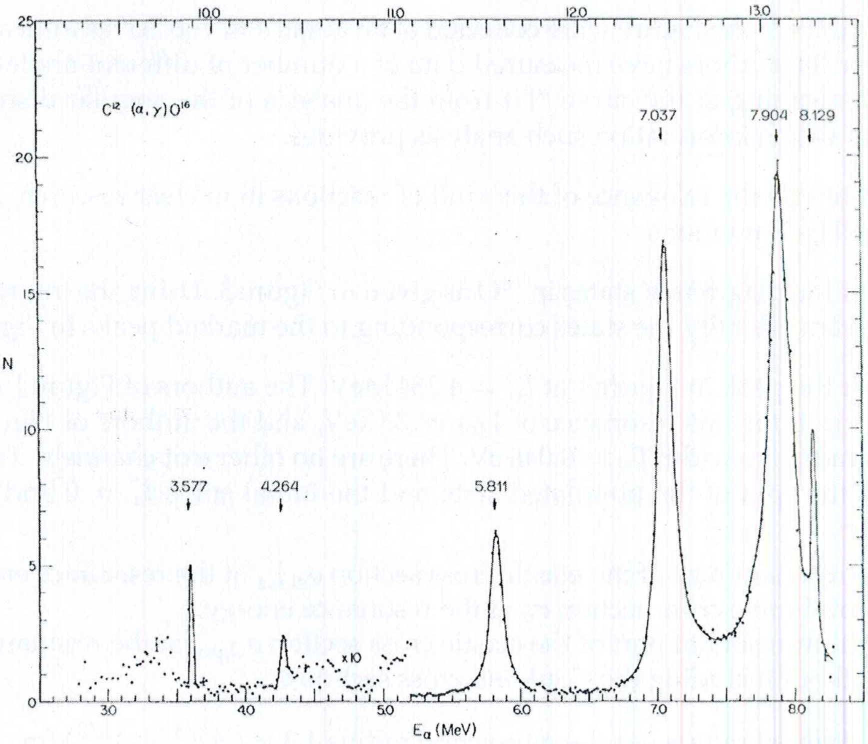

Figure 2: Yield of γ rays for the $^{12}C(\alpha,\gamma)^{16}O$ reaction as function of bombarding energy. Adapted from J. D. Larson and R. H. Spear, Nucl. Phys. 56 (1964) 497.

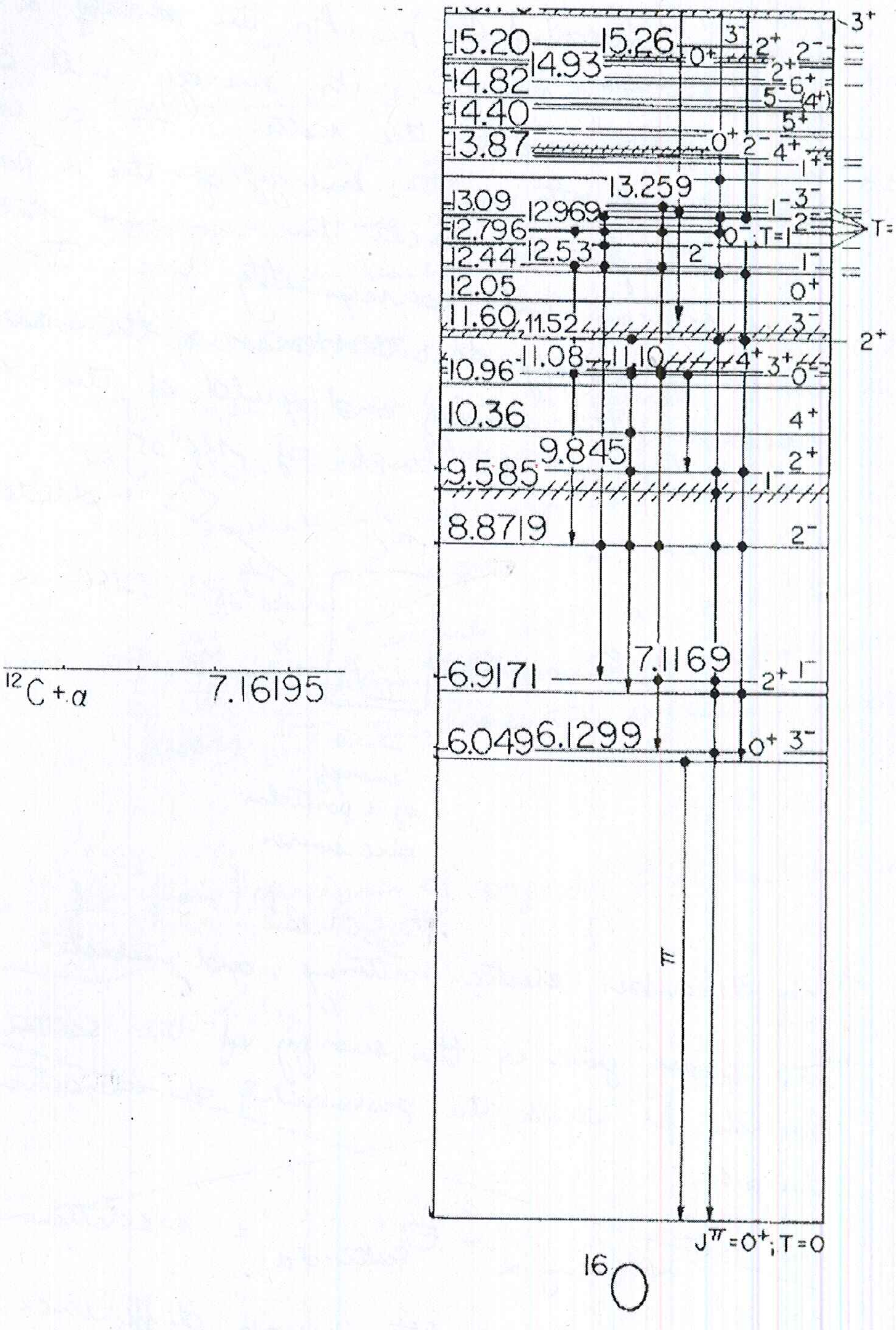

Figure 3: Energy level diagram for ^{16}O. Adapted from D. R. Tilley et al., Nucl. Phys. A 564 (1993) 1, revised 2014.