

Physics 325 final exam, Spring 2009

Two take-home questions (due Friday 3/6 5 pm)

In-class exam Thursday 3/5: about 30 minutes open-book, 30 minutes closed-book

Topics from first exam fair game, plus these topics below

There will be some (considerable) choice on the open-book part

Open-book, notes, and assignments questions:

Apply momentum and energy conservation laws to decays

Calculate Q values for any reaction or decay, given a table of atomic masses

Given a diagram of excited states (with spins and parities) for a given nuclide, be able to explain which might be single-particle shell model states and which are not (i.e. involve several excited particles or collective motion such as rotation or vibration)

Estimate the gravitational potential energy released in contraction that's available to heat a typical star (given the mass and radius)

Calculate the Coulomb barrier for a given fusion reaction; given a temperature, compare the Coulomb barrier to typical kinetic energies available because of thermal motion; explain why fusion can happen if the Coulomb barrier is greater than kT (two reasons)

Use the energy released in a reaction to calculate the mass needed to produce a certain amount of energy (or vice versa)

Calculate the amount of shielding required to reduce the intensity of an X or gamma-ray beam

Know the difference between activity, absorbed dose, and equivalent dose; calculate doses and estimate their biological effects (increase in cancer probability)

Closed-book questions (may be OK to use Chart of Nuclides and periodic table)

For α , β , and γ decay, have an idea of what determines the half-life; be able to write out typical decay processes and explain what type of nuclei typically undergo those decays and why

Describe internal conversion

Define isomeric (metastable) states; given a diagram of excited states (with spins and parities) for a given nuclide, identify which states are most likely to be metastable

Determine which nuclides are most likely to undergo induced fission after capturing a low-energy (thermal) neutron, and explain why

Interpret the cross-section graphs on p. 117 to explain why fast neutrons are needed for inducing fission on ^{238}U , but slow (thermal) neutrons are needed for inducing fission on ^{235}U ; explain what

other processes can compete with fission in removing neutrons from natural U before they can slow enough to cause ^{235}U to fission

Describe the physics behind and materials used for the following parts of a thermal fission reactor: the moderator, coolant, control rods. Explain why light-water reactors need enriched uranium (and what “enriched” means)

Describe the induced fission process, including the energy released, what happens to the fission fragments, prompt and delayed neutrons. Explain why the delayed neutrons are important. Explain where the nuclear waste associated with a fission reactor comes from

Describe the pp cycle and the CNO cycle in terms of their net effect (no need to memorize all the steps); explain why the CNO cycle is understood in terms of catalysis

Describe in general terms the cycles of contraction, increased temperature, and fusion of increasingly higher-Z elements beyond 4He ; describe the new process that kicks in at ^{28}Si

Explain why fusion does not continue past $A=56$

Give a sense of how some elements past $A=56$ are built up (the r and s processes)

Describe the reactions being investigated for fusion power, and explain in general terms how the high density and confinement times needed for fusion are generated (magnetic confinement, inertial confinement)

For a given fusion reaction, explain whether the weak or strong interaction is responsible

For a given weak reaction or decay, explain whether the emitted neutrinos are monoenergetic or have a range of energies and why

Explain why neutrinos are an important probe of solar physics

Show why the dominant interaction of charged particles with materials is with their electrons, not with their nuclei (volume each occupies)

Compare the behavior of heavy charged particles (α , p, ions), electrons, and gamma rays in materials (range, energy loss mechanisms, amount of deflection)

Explain what the Bragg peak is in the range of heavy charged particles, and what the physics behind it is

Describe the three ways gamma rays interact with materials, and have an idea of their relative energy dependence

Distinguish between ionizing and non-ionizing radiation

Describe how ionizing radiation causes biological damage on the cellular level, and what the biological effects of that damage can be

Explain why alpha particles are more biologically damaging than electrons or gamma rays of the same energy

Describe major sources of exposure to ionizing radiation