Nuclear Reactor Theory

2006 년 1 학기

Midterm Examination

April 19, 2006

Answer to the following questions as **concisely** (briefly) as possible by using **key words**.

1. Give the proper value to the following questions; value only, no need for derivation. (10 points)
   a. 1 MeV, 1 barn, and 1 Fermi in SI unit
   b. Average energy of fission neutrons in MeV
   c. Recoverable fission energy from 1 gram of U-235 in MWD

2. Explain the following terms with the corresponding unit. Use appropriate mathematical expressions if necessary. (20 points)
   a. Microscopic cross section, Macroscopic cross section
   b. Angular flux $\varphi(\vec{r}, E, \hat{\Omega})$, Scalar flux $\phi(\vec{r}, E)$ and Current $\vec{J}(\vec{r}, E)$
   c. Mean free path (Derive it from the total macroscopic cross section.)
   d. Fick's Law (Explain it's limitations as well.)

3. Answer the following questions regarding nuclear reactions. (30 Points)
   a. The neutron energy available to a nuclear reaction is not the whole kinetic energy of the incident neutron. Give the available energy in terms of the atomic mass number of nucleus, A. Let the mass of the neutron be m and the speed be v. Of course, it is assumed that the mass of the nucleus is Am. Give the reason for your answer.
   b. Classify the types of nuclear reactions.
   c. Explain the resonance behavior of nuclear reactions with an emphasis on the reason why it is more important for heavier nuclides.
   d. Draw the energy dependence of the scattering cross section near a resonance with a brief explanation of each part.
   e. Explain the fission process with an emphasis on the critical energy. Why are some odd numbered heavy nuclides easier to fission?

4. Give the 3-D Boltzmann transport equation and explain each term with a particular emphasis on the leakage term by showing how it is derived to such form. (10 Points)

5. Based on the assumption of the linear dependence of angular flux on the cosine of the polar angle in the plane geometry, derive the specific dependence in terms of scalar flux and net current. Then derive the total outgoing current at the surface on the positive side (right hand side) boundary. (10 Points)

6. Give the two-group diffusion equation with an eigenvalue attached to the suitable term. Then explain the need and role of the eigenvalue. (10 Points)

7. Derive the equation that determines the energy dependence of flux, namely the spectrum, starting from the continuous energy form of neutron diffusion equation based on the assumption of separability. Then explain how the infinite medium spectrum, fundamental spectrum, and lambda-mode spectrum can be obtained. Draw the three spectra. For lambda mode, assume $\lambda < 1$. (10 Points)