Nuclear Reactor Theory

2008 년 1 학기

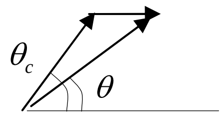
Midterm Examination 1

April 3, 2008

1. Explain the following. Give proper units when required. (32 points, 4 each)
   a. Microscopic and macroscopic cross section. (Unit)
   b. The reason why the scalar flux is considered more important than the angular flux. (Unit)
   c. Potential scattering and compound scattering
   d. The reason for pronounced resonance absorption in heavy nuclei.
   e. Classification of nuclear reactions with proper representation of each reaction in symbols.
   f. Critical energy needed for fission and the reason why fissile nuclides are all odd-numbered.
   g. Decay heat
   i. Resonance self-shielding

2. Compute the following. Use 0.6×10^{24} for the Avogadro number. (12 points, 4 each)
   a. Mean free path of a 1 keV neutron in water at the room temperature given that the total cross section of O-16 is almost constant at 4 barns in the intermediate energy. (4)
   b. Average number of collisions required for a neutron to lose energy from 1 MeV to 1 eV by elastic scattering in a graphite medium. (4)
   c. Energy recoverable in MWD by fissioning all nuclei in 1g of U-235.

3. Derive the following. (27 points, 5 each, indicated otherwise)
   a. The relation between the cosines of the scattering angle in the lab and CM system: $\mu = \dfrac{1 + A\mu_c}{\sqrt{1 + 2A\mu_c + A^2}}$.



   b. Scattering kernel $K(u' \to u)$ in case of isotropic scattering in CMS. Use the following relations for the derivation: $\mu_c = \dfrac{1}{2A}\left(\dfrac{E}{E'}(A+1)^2 - (A^2+1)\right)$ and $du = -\dfrac{dE}{E}$. (6)

   c. Energy dependence of Maxwellian flux spectrum. Start from the Boltzmann distribution, $P(v_x, v_y, v_z) = Ce^{-\frac{E}{kT}}$ where $E = \dfrac{1}{2}m(v_x^2 + v_y^2 + v_z^2)$. Find the final normalization constant. (6)

   d. Slowing down density for the 1/E spectrum given by $\varphi(E) = \dfrac{S_0}{\xi\Sigma_s E}$ for a single isotope moderator region.

   e. $\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$.

4. Plot schematically the following and answer associated questions. (12 points, 4 each)
   a. Neutron spectrum in thermal reactors. Indicate clearly your axis labels. Provide approximate value for distinct energy region boundaries
   b. $\eta(E)$ for enriched fuel. Indicate approximate ticks on the y-axis. What is the consequence of this plot?
   c. Fission spectrum in semi-log scale. Indicate the most probable and average fission neutron energies.

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5. Solve the following slowing down equation for a fuel and hydrogen mixture and answer the associated questions. (17 Points)

$$\Sigma_t(E)\varphi(E) - \int_E^\infty \frac{\Sigma_s^H(E')\varphi(E')}{E'}dE' = \chi(E)s_0 \quad \text{where} \quad \Sigma_t(E) = \Sigma_a^F(E) + \Sigma_s^H(E)$$

a. Obtain the solution for the energy region below the fission source range. (9)
b. Give the non-absorption probability and explain its variation during slowing down with a drawing. (4)
c. What is the virgin or uncollided flux? (4)