Phys487 Final Exam

Problem 1: Comprehension

- **a.** Why light nuclei are better moderators than heavy nuclei?
- **b.** What effect does the presence of the fuel have on the diffusion of neutrons (scattering and absorption)؟
- **c.** What is the physical interpretation of the mean free path of a neutron when interacting with matter?
- **d.** Explain the role of the reflector in a reactor core?
- **e.** What is the cause of the neutron diffusion in a reactor assembly?
- **f.** What is the physical meaning of the thermal diffusion length and fast diffusion length?
- **g.** On which basis the reactors are classified?
- **h.** Using a simple useful equation, demonstrate that the energy transfer between a neutron and a heavy nucleus is almost zero?

Problem 2:

An indium foil of 2 cm^2 cross section and 10^{-3} cm thickness is exposed to a broad beam of neutrons of uniform energy. If the neutron flux is $5\times10^9\ neutrons/cm^2\ \sec$ and the microscopic absorption cross section for these neutrons is 190 *barns*, calculate the number of neutron captures that will occur during a 3 min exposure of the foil. For ^{115}In, $\rho = 7.29\ gr/cm^3$.

Problem 3:

It is desired to reduce the intensity of a thermal neutron beam by a factor of 1000 by interposing a cadmium foil with a thickness of 0.061 cm. Calculate the microscopic absorption cross section for cadmium. For Cadmium: $\rho = 8.65\, gr/cm^3$, $M = 113\ gr$.

Problem 4:

Starting a neutron cycle with 1000 fast fission neutrons (first generation). Calculate:

a) the number of neutrons produced by fast fissions
b) the number of neutrons absorbed in uranium fuel before reaching thermal energies
c) the number of neutrons reaching thermal energies
d) the number of thermal neutrons absorbed in fuel
e) the number of neutrons escaping through fast leakage
f) the number of neutrons escaping through thermal leakage
g) the number of fast fission neutrons of the second generation

$\varepsilon = 1.029$, $p = 0.889$, $f = 0.910$, $l_f = 0.956$, $l_{th} = 0.945$, $\eta = 1.34$

Problem 5:

1) Calculate the diffusion length for thermal neutrons in graphite used as a moderator, if

$\sigma_a = 3.2\ mb$; $\sigma_s = 4.8\ barns$; $\rho_{graphite} = 1.62\, gr/cm^3$.

2) How much the diffusion length become when we consider a homogeneous mixture of

1 atom of U^{235} per 10^4 atoms of graphite, if $\sigma_a^{U^{235}} = 698\, barns$

3) Compare and discuss the results found in a) and b).

Problem 6 :

Consider a critical thermal cubic reactor employing U^{235} and graphite in an atom ratio of 1: 100000.

1) Calculate the total leakage (fast and thermal).
2) Calculate the extrapolation length (distance).
3) Calculate the critical size if $B = 0.018$.
4) Calculate the critical mass of U^{235}.

Graphite: $\sigma_a = 0.003\, barn$; $L_m = 54\, cm$; $\tau_0 = 364\, cm^2$; $\lambda_s = 2.60\, cm$; $\rho_m = 1.62\, gr/cm^3$

Uranium: $\eta = 2.08$; $p = 1$; $\varepsilon = 1$; $\rho_u = 18.7\, gr/cm^3$, $\sigma_a^{U^{235}} = 698\, barns$.

Some useful equations and quantity values

$$\overline{E} = \frac{3}{2}kT \quad \left(\overline{v^2}\right)^{1/2} = v_{rms} = \left(\frac{3kT}{m}\right)^{1/2}$$

$$\Delta T = T_n - T = 0.89T \cdot A \cdot \left(\frac{\sum_a}{\sum_s}\right)$$

$$\frac{E_1}{E_0} = \frac{v_1{}^2}{v_c{}^2} = \frac{1 + A^2 + 2A\cos\phi}{(1+A)^2}$$

$$\frac{(A-1)^2}{(1+A)^2} = \alpha$$

$$\overline{\left(\frac{\Delta E}{E}\right)} = \left(\frac{E - E_0}{E}\right) = \left(\frac{1-\alpha}{2}\right)$$

$$\xi = \overline{\log\left(\frac{E_0}{E}\right)} = \frac{\int_E^{E_0} \log\left(E_0/E\right) P(E)dE}{\int_E^{E_0} P(E)dE}$$

$$sdp = \frac{\xi}{\lambda_s}$$

$$d = 0.71\lambda_{tr}$$

$$\lambda_{tr} = \frac{\lambda_s}{1 - (2/3A)}$$

$$L^2 = \frac{\lambda_{tr}\lambda_a}{3}$$

$$f = \frac{1}{1 + \frac{\Sigma_{am}}{\Sigma_{a0}}}$$

The geometrical buckling for a parallelepiped of sides *a, b and c* is given by:

$$B^2 = \frac{\pi^2}{a^2} + \frac{\pi^2}{b^2} + \frac{\pi^2}{c^2}$$

بالتوفيق