Problem Set 2

Reactor Physics Review + Thermal Parameters

Reference Textbooks:

[RAK] = Knief, R. A. *Nuclear Engineering: Theory and Technology of Commercial Nuclear Power* 2nd ed. La Grange Park, IL: ANS, 2008. ISBN: 9780894484582.

1) A spherical reactor composed of U-235 metal is operating in a critical steady state. Using the k_{eff} formula derived in class as your guide, discuss what probably happens to the multiplication factor of the reactor and why, if the system is modified in the following ways (treat each modification separately, not cumulatively): (a) an overweight operator accidentally sits on the reactor, squashing it into an ellipsoidal shape, (b) a sheet of cadmium is inserted in the reactor, (c) another identical reactor is placed a short distance from the original reactor, and (d) one simply leaves the reactor alone for a period of time.

   (Adapted from Duderstadt and Hamilton text.)

2) What is the maximum value of the multiplication factor that can be achieved in any conceivable reactor design which uses U-235 as its fuel? What if one uses Pu-239 fuel?

   Useful information for this problem:

Isotope	Neutrons emitted per fission, $\bar{\nu}$		Fission cross section (b)		Capture cross section (b)	
	Thermal	Fast	Thermal	Fast	Thermal	Fast
U-235	2.43	2.65	577	1.4	101	0.25
Pu-239	2.87	3.15	741	1.8	274	0.26

   (Adapted from Duderstadt and Hamilton text.)

3) Consider an infinitely large homogeneous mixture of U-235 and a moderating material. Determine the fuel-to-moderator ratio (i.e. ratio of number densities) that will render this system critical for the following moderators: (a) graphite, (b) beryllium, (c) water (H_2O), and (d) heavy water (D_2O). Assume $\sigma_f = 577$ b and $\sigma_a = 678$ b for U-235 + use the thermal cross section data given in the table below for H_2O, D_2O, Be and C.

   (Adapted from Duderstadt and Hamilton text.)

4) Given the results in Problem 3 above, why is light water such a popular moderator?

5) [RAK] Chapter 7, Problem 7-5

6) [RAK] Chapter 7, Problem 7-10

Useful Reference - Table: 2200m/sec CROSS SECTIONS FOR NATURALLY OCCURRING ELEMENTS [From *Reactor Physics Constants, ANL-5800* (1963)].

Duderstadt, J. J., and L. J. Hamilton. *Nuclear Reactor Analysis*. Hoboken, NJ: John Wiley & Sons, Inc., 1976. ISBN: 9780471223634.

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