ASSIGNMENT 2

1(a) Show that the energy released in the n^{th} generation of a fission chain reaction, initiated by one fission (0^{th} generation) is given by $E_n = k^n E_R$: where k is the multiplication factor and E_R is the recoverable energy per fission. (The first neutron is considered as generation - 0)

(b) Show that the total energy released up to and including the 0^{th} and n^{th} generation is given by

$$E_n = \frac{k^{n+1} - 1}{k - 1} E_R$$

2(a) Show that the fraction F, of the energy released in a super critical chain reaction that originates in the final m generation of the chain is given approximately by $F = 1 - k^{-m}$, provided the total number of generations is large.

(b) Most of the energy from a nuclear explosion is released during the final moments of the detonation. Using the result of the previous problem, compute the number of fission generations required to release 99 percent of the total explosive yield. Use the nominal value k = 2. (6.64 generations)

(c) If the mean time between generation is in the order of 10^{-8} sec, over what period of time is energy released during a nuclear explosion? (6.64 X 10^{-8} s)

3. The fission product I^{131} has a half life of 8.05 days and is produced with a yield of 2.9 %(0.029 atoms per fission). Calculate the equilibrium activity of this isotope in a reactor operating at a thermal power of 3300 MW (Assume no other source for this isotope and the isotope is removed by radioactive decay alone)

4(a) Define of the 'Q' value of a nuclear reaction:

$$X_1 + X_2 \longrightarrow X_3 + X_4$$

(b) Some tables tabulate the mass excess 'Δ', defined as the M-A, where M and A are the rest mass of the neutral atom and the mass number of a given element expressed in energy units respectively. Derive a relation for the Q value in terms of $\Delta_{X_1}, \Delta_{X_2}, \Delta_{X_3}$ *and* Δ_{X_4}

(c) Given the values of Δ's of $^3H, ^2D, ^4He$ and ^1n are 14.950, 13.136, 2.425 and 8.071 MeV respectively, compute the Q value for the reaction,

$$^3_1H + ^2_1D \longrightarrow ^4_2He + ^1_0n$$

(d) Compute the binding energy of the last neutron for $^{236}_{92}U$, given that the Δ values in MeV for $^{235}_{92}U$, $^{236}_{92}U$ and ^1_0n are 40.93, 42.46 and 8.071 respectively.

5. Assuming that the fissioning nucleus is ^{235}U, compute the value of β, defined as the mass of the fuel consumed per unit energy release. You may assume that 200 MeV is released per fission and the value of capture to fission ratio is 0.17. (1.425 X 10^{-14} kg/W-s)

6. Because of an error in its design, a thermal reactor that was supposed to breed on the ^{232}Th-^{233}U cycle unfortunately has a breeding ratio of only 0.96. If the reactor operates at a thermal power level of 500 MW, how much ^{232}Th does it convert in one year? Capture to fission ratio for U-233 = 0.09 (199.2 kg)

7. What value of the breeding gain is necessary for a fast breeder operating on the ^{238}U-^{239}Pu cycle to have an exponential doubling time of 10 years, if the specific power for this type of reactor is 0.6 MW/kg of ^{239}Pu? Capture/fission ratio for PU-239 = 0.42 (G = 0.208)