Lamarsh solution chap7

LAMARSH SOLUTIONS CHAPTER-7 PART-1 7. 1 Look at example 7. 1 in the textbook, only the moderator materials are different Since the reactor is critical, k ? ? ? T f ? 1 ? T ? 2. 065 from table 6. 3 so f ? 0. 484 We will use t d ? t dM (1 ? f) and t dM from table 7. 1 t dM, D2O ? 4. 3e ? 2; t dM, Be ? 3. 9e ? 3; t dM, C ? 0. 017 Then, t d, D2O = 0. 022188sec; t d, Be = 2. 0124e-3sec; t d, C ? 8. 772e ? 3sec 7. 5 One? delayed? neutron group reactivity equation; ?? ? lp 1 ? ? lp ? ? ? where ? ? 0. 0065; ? ? 0. 1sec? 1 1 ? ? lp ? ? ? For lp ? 0. 0sec For lp ? 0. 0001sec For lp ? 0. 001sec Note: In this question examine the figure 7. and see that to give a constant period value , say 1 sec, you should give much more reactivity as p. neutron lifet ime increases. And it is strongl recommended that before exam, study figure 7. 1 . 7. 8 ? ? 2e ? 4 from figure 7. 2 so you can ignore jump in power(flux) in this positive reactivity insertion situation t P Pf ? Pi e T then t= ln f ? T ? 3. 456hr Pi 7. 10 In eq 7. 19 prompt neutrons:(1-?)k ? ? a ? T delayed neutrons: p? C ? in a critical reactor(from 7. 21) ? k ? ? dC ? 0 ? C ? ? a T ? p? C ? ? k ? ? a ? T dt p? ? s T ? (1-?)k ? ? a ? T ? ? k ? ? a ? T ????? ? ?? ? ? ?? prompt delayed

Now you can compare their values prompt (1-?) ? delayed ? LAMARSH SOLUTIONS CHAPTER-7 PART-2 7. 12 ?? P0? ??? t ?? 1 P(t) ? e in here ? ? then, and ? ? ??? ??? T t P0 T P(t) ? e in here take T=-80sec ? 1? ? t ? P0 P0 ? 10 ? e 80 ? t ? 25. 24 min . 1 ? (? 5) ? 9 7. 14 k ? , 0 ? ?? pf 0 , critical state k ? , 1 ? ?? pf1 , original state ?? k ? , 1 ? 1 k ? , 1 ? k ? , 1 ? k ? , 0 k ? , 1 ? ?? pf1 ? ?? pf 0 f ? 1? 0 ?? pf1 f1 ? a1F ? a 0 F f1 ? F f0 ? and we know ? a1F = 0. 95 ? a 0 F and finally, M F M ? a1 ? ? a ? a 0 ? ? a f0 1 0. 95? a 0 F ? ? a M 1? ? 1? ( ) f1 0. 95 ? a 0 F ? ? a M 7. 16 20 min? 60sec/ min ? 1731. 6sec. ln 2)From fig 7. 2 rectivity is small so small reactivity assumption can be used as, 1 1 T= ? ? i t i ?? ? ? 0. 0848(from table 7. 3)= 4. 89e-5= 4. 89e-3% ? i 1731. 6 4. 89e-5 also in dollars= ? 7. 52e ? 3$? 0. 752cents 0. 0065(U235) t T a)2P0 ? P0e ? T ? 7. 17 8hr ? 60 min? 60sec 8hr ? 60 min? 60sec ? T? ? 6253. 8sec(very large) T ln100 b)We will make small reactivity insertion approximation using the insight given by figure 7. 2 for U-235 so, 1 1 T= ? ? i t i ?? ? ? 0. 0324(from table 7. 3)= 5. 18e-6 ? i 6253. 8 a)100MW ? 1MWe 7. 18 a)From fig 7. 1 when ? ? 0 ? 1 ? 0 so T= 1 ? T?? ? 1 b)Use prompt jump approximation, t t

P0? T P0 T 10watts (300? 100)sec P(t)= e? e? e 100sec ? 82watts ? 0. 099 ??? 1? 1? ? 1 c)Use T=-80sec. 300)sec t t P0? T P0 T 82watts ? (t ? 80sec P(t)= e? e? e ? 8 ??? 1? 1 ? (?) ? 1 LAMARSH SOLUTIONS CHAPTER-7 PART-3 7. 20 Insert 7. 56 into 7. 57 and plot reactivity vs rod radius Using eq. 7. 57 and 7. 56 we plotted and found the radius value for 10% reactivity= 3. 9 cm reactivity vs rod radius(a) 0. 14 0. 12 X: 3. 9 Y: 0. 1004 reactivity 0. 1 0. 08 0. 06 0. 04 0. 02 0 0 0. 5 1 1. 5 2 2. 5 rod radius 3 3. 5 4 4. 5 5 7. 23 a)For a slab this equation is solved you know as, x xq ? T (x) ? A1 sinh( ) ? A 2 cosh( ) ?

T then to find the constants you must introduce L L ? a 2 boundary conditions 1 d? T 1 d? T 1 B. C. 1: ? 0 @ x= 0 and B. C. 2: ? ? @ x=(m/2)-a ? T dx ? T dx d Introducing B. C. 1 you find A1 ? 0 and B. C. 2 x ? ? cosh( ) ? ? q L A2=- T ? 1 ? ? d ? a ? sinh((m ? 2a) / 2L) ? cosh((m ? 2a) / 2L) ? ? L ? So finally, x ? ? cosh( ) ? ? qT L ? T (x) ? ? 1 ? ? d ? a ? sinh((m ? 2a) / 2L) ? cosh((m ? 2a) / 2L) ? ? L ? b) Neutron current density at the blade surface, d? L J @(m/2)-a ? ? D T ? d dx @(m/2)-a ? coth((m ? 2a) / 2L) L Let 's follow the instructions in the question Multiply the n. current density by the area of the blades in the cell... --What is the area of the blades in the cell: From fig 7. 9, assume unit depth into the page so the cross sectional area of one of four blades, A=(l-a) ? 1 Divide by the total number of neutrons thermalizing per second in the cell ---What is the volume of the cell: From fig 7. 9, assume unit depth into the page so V=(m-2a) ? (m ? 2a) ? 1 So as in page 358 4(l ? a) 1 fR ? 2 (m ? 2a) d ? coth((m ? 2a) / 2L) L 7. 25 You should find the B-10 average atom density in the reactor Total mass of B-10= 50rods ? 500g= 25 ? 103g 25e3 N? ? 0. 6022e24 ? 1. 39e27atoms 10. 8 Atom density averaged over whole reactor volume, 1. 39e27 NB ? ? 2. e21 atoms/cm3 ? ? aB ? 2. 9e21? 0. 27b ? 7. 8e ? 4cm ? 1 4 ?(48. 5)3 3 7. 8e ? 4 ? use eq. 7. 62 then find,? w ? ? 0. 0938 ? 9. 4% 0. 00833 ? 0. 000019 7. 27 H ? 100cm and ?? ? ? 0.x ? H a) For x ? 3H / 4 ? 75cm 1 ? x ? ? Sin(2? x / H) ? ? ?? (3H / 4) ? ? 0. 4545$? H 2? ? so the positive reactivity insertion is -0. 4545$-(-0. 5$)= 0. 04545$?? (x) ? ?? (H) ? b) The rate of reactivity per cm can be found by differentiating the reactivity equation over the distance. ? 1 1 ? d ?? (x) d ? 1 ? x ?? ? ? ?? (H) ? ? Sin(2? x / H) ? ? ? ?? (H) ? ? Cos(2? x / H) ? dx dx ? ? H H ? ? H 2? ?? ? d ?? (x) ? 0. 005$ / cm ? 0. cent / cm dx x ? 3H / 4 7. 31 There is a decrease in T so let’s examine the effects of sign of temperature coefficients, If ? T ? (?) decrease in T ? decrease in k ? reduces P ? gives further dec. in k ? shut down(unstable) If ? T ? (?) decrease in T ? increase in k ? increase in P ? inc. in T and finally reactor returns to its original state! (stable) 7. 33 ? N FVF I ? p ? exp ? ? ? ? ? M ? sM VM ? I: Resonance Integral ? sM : Scattering Cross-Section of Moderator ? M : Constant 2a ? 1. 5 ? a ? 0. 75 (rod radius) dI I (300 K) ? 1 ? ? I (T) ? I (300 K)(1 ? ? 1 (T ? T0)) dT 2T I (T) ? ? ? sM ? M VM ln p N FVF T ? T0 ?

I (T) ? I (T0) ? ? k ln 0. 912 ? 0. 0921k where k ? ? sM ? M VM N FVF For slightly enriched uranium dioxide reactor take ? ? 10. 5 g / cm3 (See Chapter 6). ? 1 ? A? ? C? / a? where A? ? 61? 10? 4 and C? ? 2. 68 ? 10? 2 (Table 7. 4) ? ? 1 ? 0. 009503 T ? 665? C (? 938K) ? I (T) ? I (T0)(1 ? 13. 31* ? 1) ? 1. 1264I (T0) ? I (T) ? 0. 0921? 1. 1264 ? k ? 0. 1037k ? 1 ? ? k ? 665o C ? exp ? ? I (T) ? ? exp ? ? 0. 1037 ? ? 0. 9014 ? k ? ? k ? 7. 34 70 F ? 210C 550 F ? 287 0C d ? ?? ? T ? ? ? ?? ? (287 ? 21) ? ? 2 ? 10? 5 0C dT ? T where ? = 0. 0065 ? 1 ? ? 5. 32e ? 3 ? ? 0. 532% ? ? 0. 81$ 7. 37 First you should solve problem 7. 6 to find the fraction of expelled water, 575F ? 301 0 C 585F ? 307 C 0 Vvessel ? 6 0 C increase in T ? D 2 ? ? 6. 5m3 ? Vwater ? v 0 ? 3. 25m3 4 ? v ? ? v ? T ? ? v ? 3. 25m3 ? 3e ? 3 ? 6 0 C ? 5. 85e ? 2m3 v0 ?? ? v ? 0. 018 v0 Then find f after expelling, k ? , 0 ? ?? pf 0 , critical state k ? , 1 ? ?? pf1 , original state ?? k ? , 1 ? 1 k ? , 1 ? k ? , 1 ? k ? , 0 k ? , 1 ? ?? pf1 ? ?? pf 0 f ? 1? 0 ?? pf1 f1 ? a1F ? a 0 F f0 ? and we know ? a1F = 0. 95 ? a 0 F and finally, F M F M ? a1 ? ? a ? a 0 ? ? a f1 ? f0 1 0. 95? a 0 F ? ? a M 1? ? 1? ( ) f1 0. 95 ? a 0 F ? ? a M f0 ? ? a F ? a F ? ? a M f? in here f 0 ? 0. 682 so ? a F ? a F ? 1 ? ?)? a M ? a M 1 ? ? 1 ? a F f0 so f? 1 1 1 ? 0. 0982 ? (? 1) f0 ? 0. 956 f-f 0 ? 0. 287 f ?? 0. 287 Finally, ? T (f) ? ? 0 ? 0. 0478per 0 C ? T 6C Then ?? = LAMARSH SOLUTIONS CHAPTER-7 PART-4 7. 39 The reactivity equivalent of equilibrium xenon is to be; ? ?? ? I ? ? X ? T where ? X ? 0. 770 ? 1013 / cm2 ? sec and ? X ? 0. 00237 and ? I ? 0. 0639 ? p? ? X ? ? T ? ? 2. 42 and p ? ? ? 1 0 -0. 005 reactivity -0. 01 -0. 015 -0. 02 X: 4. 8 Y: -0. 02695 -0. 025 -0. 03 0 0. 5 1 1. 5 Note the convergence ….. 2 2. 5 3 thermal flux x 1e14 3. 5 4 4. 5 5 7. 42 For Xenon using eq. 7. 94 X? ? (? I ? ? X)? f ? T ? X ? ? aX ? T here ? I ? 6. 39e ? 2 and ? X ? 2. 37e ? 3 (from table 7. 5) ? X ? 2. 09e ? 5 (from table 7. 6) You should make a correction to the thermal absorption cross section as follows, ? 20 0. 5) 2 200 ? aX (200? C) ? 0. 886 ? 1. 236 ? 2. 65e6 ? 1e ? 24 ? 0. 316 ? a, X ? ? g aXe (200 0C) ? ? a, X (20 0C) ? (? aX (200? C) ? 9. 17e ? 19cm 2 ? 9. 17e5b finally, X? ? 0. 06627 ? ? f ? 1e13 2. 09e ? 5 ? 9. 17e5b ? 1e13 For Samarium using eq. 7. 94 S? ? ? P ? f ? aX where ? P ? 0. 01071 ? 20 0. 5) 2 200 ? aX (200? C) ? 0. 886 ? 2. 093 ? 41e3 ? 1e ? 24 ? 0. 316 ? a, S ? S ? g a (200 0C) ? ? a, S (20 0C) ? (? aX (200? C) ? 2. 9e4b finally, S? ? 0. 01071 ? f 2. 39e4b Note: When finding fission cross sections you should find the atom density of uranium 235 for this infinite thermal reactor. To do this , refer to example 6. 5 on page 294 taking buckling zero and find a relation between moderator number density and fuel density. 7. 43 Using eq. 7. 98 0. 06627 1e13 ? 2. 42 1e13 ? 0. 773e13 where p=? = 1 0. 01071 ?? 2. 42 ? Xe ? ? ? Sm 7. 44 First of all, we must write the rate equations for each element; dN Sm ? ?? Sm N Sm ? ? a Sm N Sm? T ? ? Sm ? f ? T dt dN Eu ? ? Sm N Sm ? ? Eu N Eu ? ? a Eu N Eu? T dt dN Gd ? ? Eu N Eu ? ? a Gd N Gd? T dt) For equilibrium reactivity; N (t) ? N (t ? dt) ? Xi Xi and ignore ? a Sm N Sm? T & ? a Eu N Eu? T Inserted into all rate equations; N Sm ? Sm ? f ? T ? ? Sm dN X i (t) ? 0 dt ? Sm N Sm ? ? Eu N Eu ? a N Gd Gd ? Eu N Eu ? ? T Reactivity equation is found as below; ?? ?? where ? a Gd / ? f ?? p ? Sm ?? ?? p ? Sm ? 7 ? 10? 5 and ? ? 2. 42 and ? ? p ? 1 ? ? ? ? 2. 893 ? 10? 5 b) 157 Sm decays rapidly relative to 157 Eu and half-life of the 157 Sm is too small so, dN Sm ? 0 ? ?? Sm N Sm ? ? Sm? f ? T ? ? Sm N Sm ? ? Sm? f ? T dt This equation is inserted into rate equation of 157 Eu and 157 Gd ; dN Eu ? ? Sm ? f ? T ? Eu N Eu dt dN Gd (t) ? ? Eu N Eu ? ? a Gd N Gd? T dt Gd At shutdown ? N0Eu & N0 are equal to equilibrium concentration for 157 Eu and 157Gd . ? No fission & no absorption is observed. From rate equation of From rate equation of Eu ? N

157 157 Gd Eu ? N Eu ? ? Eu t 0 (t) ? N e Gd (t) ? N Gd 0 ? Sm ? f ? T ?? Eu t ? e ? Eu ? Sm ? f ? T Eu ? (1 ? e?? t) ? Eu From equilibrium of Gd ? N 157 Gd 0 ? Sm ? f ? ? a Gd ? Sm ? f ? Sm ? f ? T Eu ? N (t) ? ? (1 ? e?? t) ? a Gd ? Eu Gd Maximum reactivity is reached at time goes to infinity! Gd ? N max (t ? ?) ? ? Sm? f (?? ?? ? a Gd / ? f ?? p 1 ? a ? ? T) ? Eu Gd Sm where ? a ? ? f (1 ? ? T ? a Gd ? ? ? ?? (1 ?) /? ? Eu Sm Gd where ? T ? a Gd) ? Eu ? Eu ? 1. 162 ? 10? 5 s ? ? ? ? 4. 386 ? 10? 5 ? ? 0. 675cents 7. 47 a) For constant power; P ? ER ? ? fF (r , t)? T (r , t)dV V So as N decreases , flux should increase to keep power constant, dN F (t) ? ? N F (t)? aF ? T (t) (1) dt P ? ER ? fF (t)? T (t), ? fF (t) ? N F (t)? aF N F (t)? T (t) ? N F (0)? T (0) ? constant integrating (1) between 0, t we get, N F (t) ? N F (0) ? ? N F (0)? aF ? T (0)t ? N F (t) ? N F (0)[1 ? ? aF ? T (0)t] b) P ? ER ? fF (t)? T (t) ? T (t) ? P ER? fF 1 P 1 ? N F (t) ER? fF N F (0)[1 ? ? aF ? T (0)t]