Ref./PE/T/422/2019

BACHELOR OF POWER ENGINEERING EXAMINATION, 2019

(4th Year, 2nd Semester)

Nuclear Power Generation

Time : Three hours | Full Marks : 100

Answer any *five* questions.

1. Calculate the mass defect and binding energy for uranium-235. One uranium-235 atom has a mass of 235.043924 amu. The mass of a proton is 1.007826 amu and that of a neutron is 1.008665 amu. Use the mass defect to calculate the energy available from 1 gm of U-235. Hence calculate the amount of U-235 required to run a 1000 MWe nuclear reactor running for 1 year – assume suitable conversion efficiency from thermal to electrical power. If the reactor uses 2% enriched Uranium, what is the total amount of fuel in Tonnes required for a year?

5+5+5+5

2. Define microscopic cross section of neutron absorption and the mean free path. Deduce the formula for macroscopic cross section for a mixture consisting of x parts of an isotope of atomic weight M_1 and y parts of an isotope of atomic weight M_2
Define neutron flux and state its unit. Derive an expression relating Neutron Flux and the reactor's power density 4+6+4+6

3. State and explain the components of 4 factor formula.
Explain how each of these factors change with increasing reactor power.
Calculate the reproduction factor for a reactor that uses 10% enriched uranium fuel. The microscopic absorption cross section for uranium-235 is 694 barns. The cross section for Uranium-238 is 2.71 barns. The microscopic fission cross section for uranium-235 is 582 barns. The atom density of uranium-235 is 4.83 x 1021 atoms/cm3. The atom density of uranium-238 is 4.35 x 1022 atoms/cm3. Assume n(avg. nos. neutrons per fission) equals 2.42.

4+ 6+10

4. State the point-kinetics equations for a reactor with a single group of delayed neutron precursors and hence deduce the transfer function $\frac{\Delta n(s)}{\Delta \rho(s)}$. From the expression of the transfer function deduce what will happen if the fraction of delayed neutron precursors β equals 0.

4+10+6

5. Define reactivity and reactivity defect.

Convert the values of reactivity listed below to the indicated units.

a. 0.000653 $\Delta k/k$ to pcm
b. 0.0085 $\Delta k/k$ = % $\Delta k/k$
c. 16×10^{-4} $\Delta k/k$ =dollar

Explain over and under-moderation and state which mode results in a self-stabilizing reactor.

4+6+10

6. A reactor operates at a steady flux Φ_0 and is shut down at the instant t=0. Calculate the steady state Xe flux ant t= 0 and the flux $X(t)$ for t>0 and calculate (i) magnitude of Xenon peak and (ii) time to reach the peak.

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7. What are the problems associated with a direct cycle BWR?
What are the differences between (i) BWR fuel and PWR fuel (ii) BWR Control rods and PWR control rods.
Which of the two i.e. a BWR and a PWR uses a higher enrichment and why? 5+5+5+5

8. What are the advantages of a CANDU reactor?
With a neat schematic explain how heat removal by natural circulation can be achieved in a CANDU reactor? How are the temperatures at both ends maintained?
Why is Heavy Water used as a moderator and a coolant in a CANDU reactor?
Define the terms LOCA and LORA for a CANDU reactor. 3+7+6+4