Ref. No.: Ex/PG/NuE/T/112A/2024

Master of Nuclear Engineering 1st Year 1st Semester Examination - 2024

Reactor Physics & Engineering I

Time: 3 hrs **Full marks: 100**

Answer all questions

1. (a) Define Mass Defect and Binding Energy. What is the physical significance of Binding Energy? Explain how suitable materials for nuclear fusion and fission can be identified based on the Binding energy curve.

   (b) Write the expression of Binding Energy per nucleon? Find the Mean Binding Energy per nucleon for $_{90}Th^{232}$.

   (c) Explain stability of a nucleus. How does an unstable nucleus achieve a stable state?

   (d) What are magic and semi-magic nuclei?

   (e) Define half-life of a nucleus and derive the relationship between half-life and decay constant.

   [7+4+4+2+3= 20]

2. (a) Briefly discuss the mechanism of nuclear fission reaction.

   (b) Define critical mass and critical energy in the context of nuclear fission.

   (c) Define microscopic and macroscopic cross-sections of a nuclear reaction. Explain the physical significances.

   (d) Considering uranium to be a homogeneous mixture of 90 weight percent of U^{238} (σ_a = 2.70 b) and 10 weight percent of U^{235} (σ_a = 681 b), determine the total macroscopic and microscopic absorption cross-sections of uranium. Assume density of uranium to be 18.7×10^3 kg/m^3.

   [5+4+6+5= 20]

3. (a) What are fission products? Define fission yield.

   (b) What are prompt and delayed neutrons? How are delayed neutrons classified?

   (c) What role does delayed neutrons play after a reactor is shutdown?

   (d) What is the need of neutron moderation in a nuclear reactor? State some of the materials that are used as moderators in power reactors.

   (e) Differentiate between Infinite and Effective Multiplication factor. How are these related?

   [4+4+3+5+4= 20]

[Turn over

4. (a) Define Geometric and Material Buckling. Derive a relation between Buckling and Multiplication factor considering one-group critical equation for a bare reactor.

   (b) What do you mean by neutron flux? Draw the typical neutron flux profile in a bare reactor and reflected reactor, and define reflector savings.

   (c) Define Diffusion length and Migration Length. How are these related? What is the physical significance of these quantities?

   (d) Explain resonance and Doppler effect on reaction cross-section.

   [6+4+6+4 = 20]

5. (a) Write the point kinetic equations for a bare reactor and explain the different terms.

   (b) Define stable reactor period.

   (c) What do you mean understand by poisoning effect of a fission product? Derive a mathematical expression relating poisoning effect and multiplication factor.

   (d) Explain the phenomena of Xenon oscillation. What are the necessary conditions for xenon oscillations to occur in an operating reactor? How can the oscillations be minimised?

   [4+2+6+8= 20]