Ref No : Ex/PE/T/424/2017 (Old)

B.E. POWER ENGINEERING EXAMINATION, 4th Year , 2nd Semester (Old), 2017

NUCLEAR POWER GENERATION

Time : Three hours

Full Marks : 100

- Question 1 & 2 are compulsory.
- Attempt any 8 questions from the remaining (from Quest. 3 to 16).
- Attempt all sub-sections within one question unless specified otherwise.

1 **Attempt any five sub-questions** (each question carries 2 marks) 10

i) Explain with an equation (reaction) "beta decay" process in nuclei.

ii) What do you understand by the term "rest mass". Obtain an expression for the rest mass of an electron given ($m_e = 9.1 \times 10^{-31}\ kg$)

iii) Prove that thermal neutrons have an energy of ~ 25 meV

iv) What do you understand by the term "attenuation of gamma rays". Define the term "mass attenuation co-efficient".

v) Define "Gray" and prove that $1\ gray = 100\ rad$

vi) Sketch the basic model for a detector.

vii) State the three mechanisms with which the electromagnetic radiation undergoes interaction with matter.

vii) What do you understand by the terms Stopping Power, Range and Linear Energy Transfer

2 **Attempt any two sub-questions** (each question carries 5 marks) 10

i) What is "Q" value for a reaction. Show that single fission event is energetically more favourable than a DT fusion reaction, given $m_n = 1.00867$, $M_U = 235.04390$, $M_{kr} = 96.92120$, $M_{Ba} = 136.90610$, $m_D = 2.014102$, $m_T = 3.016049$, $m_{He} = 4.002604$, where All the masses are expressed in AMU, and D = ${}_1D^2$, T = ${}_1T^3$, He = ${}_2He^4$

ii) Define "Roentgen" and prove that 1R is that amount of radiation which results in an energy deposition of 83.7 $^{erg}/_{gm}$ of air.

iii) If the density of ${}^{238}U$ is 19 gm/cc and the microscopic scattering cross-section (σ_s) is 10 barns then compute the macroscopic cross section.

iv) Consider an alloy composed of Al (75%) and Silicon (25%). The density of alloy is 4 gm/cc. If $\sigma_a = 0.23\ barns$ for Al and $\sigma_a = 0.16\ barns$ for Si, determine the absorption cross-section for the alloy. Also determine it's mean free path.

3. Define 1 Atomic Mass Unit (amu) and obtain it's energy equivalence. What do you understand by the term "mass defect". Explain the concept of Binding Energy and sketch the plot of B.E per nucleon as a function of "A". Discuss the fusion & fission process in the context of this plot. 10

4 State the basic law governing radioactive decay, and obtain the necessary relation between the number of un-decayed atoms and the initial number of radio-active atoms. Obtain a relation between half-life and the decay constant. Define mean life and obtain an expression for the same. 10

5.		For the elastic scattering from neutrons derive the relation $$E_f = \frac{E_0}{(A+1)^2}\left[\cos\theta + \{A^2 - \sin\theta^2\}^{1/2}\right]^2$$ Where the quantities have their usual significance. Hence, bring out the relevance of light nuclei as moderators.	10
6.		State and explain the 4 factor formula describing all its relevant terms and explain its extension to a real life reactor.	10
7.		Describe the nuclear fission chain reaction showing all the stages with special emphasis on Fission Fragments, fast and thermal neutrons, prompt and delayed neutrons, number of neutrons per fission and the average energy released in this process. Explain why ^{238}U is suitable as fuel and nor ^{235}U.	10
8.		Describe a generalized nuclear reactor stating and describing its various components. What do you understand by the term "reactor period" What is "prompt critical condition". Explain briefly the term "prompt jump".	10
9.		State the main advantage of Heavy Water Reactor. Also highlight the problems with such reactors. How have these been circumvented in CANDU reactors. Give the schematic of the CANDU reactor, explaining briefly "calandria tube" and "gas filled annulus"	10
10.		Explain the principle and operation of a Fast Breeder Reactor. Describe briefly the desirable and undesirable characteristics of Liquid Na as a coolant. Enumerate the need for two Na loops and sketch either the Loop Design or the Pool Design for LMFBR. Define the Conversion ratio and state the condition for breeding Describe Prismatic and Pebbel Bed fuel used in Gas Cooled Reactors	10
11.		What do you comprehend by "multiple barriers" in reactor safety. State briefly the various barriers and how do they help in reactor safety. What are the "three levels of defense" in the design of a reactor. Clearly state their principles and how are these achieved. Describe briefly the three accidents that have occurred till date in context of nuclear reactors.	10
12.		What are "Control Rods" and state its two primary uses. What are the elements used for these rods. Briefly explain the different types of Control rods. What is "differential and integral control rod worth". What are Cruciform control rods.	10
13.		How is ^{135}Xe produced in a reactor core. Write the differential equation governing the buildup of ^{135}Xe with time and hence deduce its equilibrium concentration.	10
14	a)	What do you understand by the term "microscopic" and "macroscopic cross-sections". State their respective units.	5
	b)	How is the radius of the nucleus related to the mass number (A) Prove that the nuclear density is constant for all nuclei.	5

15. a) What are the two mechanisms by which radiation affects an organelle. 2

b) Describe briefly the possible effects of radiation on cells. 3

c) What do you mean by Acute Radiation Syndrome (ARS) and the what are the required conditions. 2

c) Describe briefly (i) cell cycle and cell death ; (ii) cell survival curves. 3

16 a) Using the data in the following table compute the atomic weight of naturally occurring oxygen. 5

Isotope	Abundance (%)	Atomic weight
^{16}O	99.759	15.99492
^{17}O	0.037	16.99913
^{18}O	0.204	17.99916

b) Calculate the Binding energy of the last neutron in ^{13}C, given m_n = 1.00866 a.m.u, and $M(C^{13}) = 13.00335\ amu$. 5