Indian Institute of Technology, Delhi
Centre for Energy Studies

ESL 734: NUCLEAR ENERGY

Minor-2 Examination
Duration: 60 minutes

Marks: 20
21 Mar. 2016

Answer all questions

SECTION – A

1. In a breeder reactor:
   (a) Derive the relation between breeding gain (G) and exponential doubling time (t_{De}) of a breeder reactor. Given w is fuel consumption rate per unit power and β is specific power or power produced from unit mass.
   (b) Use the above derived relations to find out the breeding gain of a U^{238}/Pu^{239} fast breeder reactor which has an exponential doubling time of 5 years and consuming 1 kg of Pu^{239} per day to operate at full power? The reactor contained 500 kg of plutonium at its initial start-up. **[3+2]**

2.
   (a) Draw the diagram of resource utilization cycle of a converter reactor. Hence show that the nuclear resource utilization U of a converter reactor which is self-sustaining on fertile material only is independent of conversion ratio C. **[1+3]**
   (b) Show how the amount of tail uranium (M_T) is related to the amount of feed uranium (M_F) in an enrichment plant. The enrichment weight fraction of U^{235} are x_F, x_P and x_T respectively for the feed, enriched product and tail uranium. Hence compute how much feed UO_2 is required to produce 10000 kg of 3 w/o enriched uranium with tail enrichment 0.2 w/o. Natural uranium is enriched with 0.711 w/o. **[1.5+1.5]**

SECTION – B

1. What is the difference between stochastic and non-stochastic radiation processes? Give some examples of both processes. **[3]**

2. Consider an infinite slab of thickness 2a, which has an infinite planar source at its center emitting S neutrons per cm^2/sec. Assume a coordinate system with its origin being at the center of the slab; with the flux vanishing at a surface outside the slab surface edges; i.e. at a distance `d' from the surface edge:

   (a) Derive an expression to determine the neutron flux in this slab.
   (b) Derive an expression for the number of neutrons that leak per second per unit area from both sides of the slab.
   (c) What is the probability that a source neutron will leak from the slab?

   [3+1.5+0.5]

Given the following constants:

Avagadro's number, $N_A=6.022 \times 10^{23}$ /mol
Boltzmann constant, $k_B= 1.38 \times 10^{-23}$ J/°K
Electron charge, $q=1.602 \times 10^{-19}$ C
Electron rest mass, $m_e=9.109 \times 10^{-31}$ kg=0.00549 amu
Proton rest mass, $m_p=1.672 \times 10^{-27}$ kg=1.007276 amu
Neutron rest mass, $m_n=1.675 \times 10^{-27}$ kg=1.008665 amu
Speed of light, $c=2.9979 \times 10^{8}$ m/s
1 eV=1.602×10^{-19} J
Planck constant, $h=6.6261 \times 10^{-34}$ J-s
Atomic weight of $^{235}_{92}U$ =235.0439 amu
Atomic weight of $^{238}_{92}U$ =238.0508 amu
Atomic weight of $^{16}_{8}O$ =15.9994 amu