Bago University
Department of Physics
First Semester Examination, March 2019

Fourth Year (BSc)
(Physics Specialization)

Phys 4103
Nuclear Physics
Time Allowed: (3) Hours

Answer any <u>Six</u> questions.

1 (a) Explain briefly various types of neutron producing reactions with an example.

(b) Calculate the neutron separation energies for each of the following nuclei.

$^3H, ^{10}Be, ^{40}Ca$

[$M(^3H) = 3.016050$ u, $M(^{10}Be) = 10.013534$ u, , $M(^{40}Ca) = 39.962584$ u, $M(^2H) = 2.014102$ u, $M(^9Be) = 9.012186$ u, $M(^{39}Ca) = 38.970691$ u, $m_n = 1.008665$ u]

2 (a) Classify different types of neutrons according to their kinetic energy and explain any two types of these neutrons.

(b) The atomic masses of boron 10 and lithium 7 are 10.01294 u and 7.01600 u respectively. The mass of a neutron is 1.008667 u. Show that the release of α-particles from boron 10 can be accomplished by neutrons of thermal energies. [$M_\alpha = 4.002603$ u]

3 (a) *Explain the attenuation of neutrons.*

(b) Calculate the macroscopic scattering cross section for neutrons of a certain energy in H_2O, assuming the following values for the microscopic scattering cross sections of H and O, respectively: $\sigma_O = 4.2$ b; $\sigma_H = 38.0$ b.

4 (a) The neutron beam intensity I is incident on a target material of area A, thickness t and having N_0 nuclei per cm^3. Determine the cross section per nucleus.

(b) A monoenergetic beams of neutrons, $\phi = 4 \times 10^{10}$ neutrons/cm^2 s, impinges on a target 1 cm^2 in area and 0.1 cm thick. There are 0.048×10^{24} atoms/cm^3 in the target and the total cross section at the energy of the beam is 4.5 b. (i) What is the macroscopic total cross section? (ii) How many neutron interactions per second occur in the target? (iii) What is the collision density?

5 (a) Prove that the average path length for the neutrons moving in the material is equal to the mean free path.

(b) An indium foil of 2 cm^2 cross-section and 10^{-3} cm thickness is exposed to a broad beam of neutrons of uniform energy. If the neutron flux is 5×10^9 neutrons/cm^2 s and the microscopic absorption cross section for these neutrons is 190 b, calculate the number of neutron captures that will occur during a 3 min exposure of the foil. [$\rho = 7.31$ g/cm^3, M = 115]

6 (a) Write short notes on BF_3 counter and ^3He proportional counter.

(b) How many collisions are required for neutrons to loss on the average 99% of an initial energy of 2 MeV in ^9Be moderated assembly (average logarithmic energy decrement is 0.209)? Compare this with the total number of collisions required to attain thermal energies.

7 (a) Derive the relation between the scattering angles in the L-system and CM system.

(b) A point source of thermal neutrons emitting 10^3 neutrons/s is placed at the centre of graphite sphere of radius 0.1 m. Calculate the flux distribution of the thermal neutrons within the sphere, assuming it to be surrounded by a material which absorbs all the neutrons escaping through the surface of the sphere. Also calculate the fraction of neutrons which are thus absorbed. [$\sigma_s = 4.75$ b, $\sigma_a = 0.0034$ b]

8 (a) Explain intermediate neutron detection and ultra high energy neutron detection.

(b) Show that average energy loss for neutrons which have one collision with carbon nuclei is 0.1462. The average logarithmic energy decrement for carbon is 0.158.