EASTERN UNIVERSITY, SRI LANKA

THIRD EXAMINATION IN SCIENCE - 2009/2010

FIRST SEMESTER (PROPER)

(June/July 2011)

PH 303 NUCLEAR PHYSICS

Time: 01 hour.

Answer ALL Questions

You may find the following data useful:

1 MeV = 1.6×10^{-13}J

1 amu = 931.5 MeV/c^2

Avogadro number = 6.023×10^{23}

1. (A)

i. State the decay Law of radioactivity.

ii. Derive expressions for activity and half life of a radioactive sample.

iii. Plutonium (^{239}Pu) is a by-product of nuclear reactors which uses uranium fuel. Plutonium is an α-emitter with a half-life of 24,120 years. Consider existence of 1.0 kg of ^{239}Pu residue in a fission product at time t=0 and estimate the following:

(a) Number of ^{239}Pu nuclei present at t=0.

(b) Initial activity of ^{239}Pu.

(c) Time interval needed to store the fission residue until the activity of plutonium drops to a safe activity level of 0.1 Bq.

(B)

In a radioactive series nuclei A decays to nuclei B with decay constant λ_A and nuclei B decays to λ_B. Number of nuclei B exists at time t will be given by the following equation:

$$N_B = \frac{\lambda_A N_0}{\lambda_B - \lambda_A}\left[e^{-\lambda_A t} - e^{-\lambda_B t}\right]$$

Where N_0 is the number of nuclei A exist at time t=0 and initially number of nuclei B exists is zero.

i. Show that the number of nuclei would be maximum at $t = t_m$ where:

$$t_m = (\lambda_B - \lambda_A)^{-1} ln\left(\frac{\lambda_B}{\lambda_A}\right)$$

ii. Consider the radioactive chain

$$^{235}_{92}U \rightarrow {}^{231}_{90}Th \rightarrow {}^{231}_{91}Pa$$

iii. Determine the number ratio $^{231}_{90}Th$ nuclei to $^{235}_{92}U$ atoms at 50 hours if initially the number of $^{231}_{90}Th$ nuclei exists is zero. The half life of Uranium and Thorium are $7.13 \times 10^8 Years\ and\ 25.5\ hours$ respectively.

2. i. What is meant by scattering process and elastic scattering in the study of nuclear Physics?

ii. An α-particle is elastically scattered from a proton which is initially at rest. Show that:

$$\left(1-\frac{M_p}{M_\alpha}\right)P_0^2 - 2P_0P_1\cos\theta_\alpha + \left(1+\frac{M_p}{M_\alpha}\right)P_1^2 = 0$$

where P_0 and P_1 are the initial and final momentum of the α - particle respectively. θ_α is the angle between the direction of scattered α - particle and its original direction. M_p, M_α are the masses of proton and α - particle respectively.

iii. Show also that the maximum possible scattering angle θ_α is $14^o30'$.