

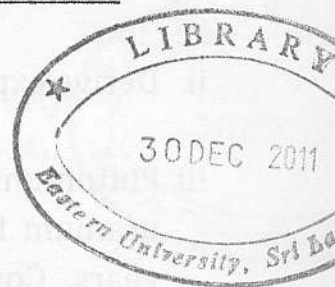
EASTERN UNIVERSITY, SRI LANKA

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:

$$1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$$

$$1 \text{ amu} = 931.5 \text{ MeV}/c^2$$

$$\text{Avogadro number} = 6.023 \times 10^{23}$$

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 use 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:

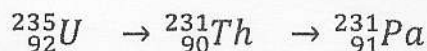
$$N_B = \frac{\lambda_A N_0}{\lambda_B - \lambda_A} [e^{-\lambda_A t} - e^{-\lambda_B t}]$$

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

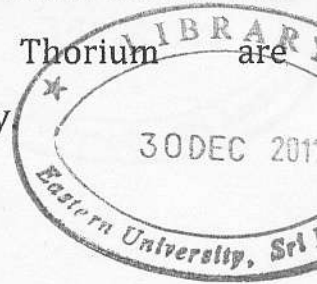
i. Show that the number of nuclei would be maximum at $t = t_m$ where:

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

ii. Consider the radioactive chain



- iii. Determine the number ratio ${}^{231}_{90}\text{Th}$ nuclei to ${}^{235}_{92}\text{U}$ atoms at 50 hours if initially the number of ${}^{231}_{90}\text{Th}$ nuclei exists is zero. The half life of Uranium and Thorium are 7.13×10^8 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 $14^\circ 30'$.